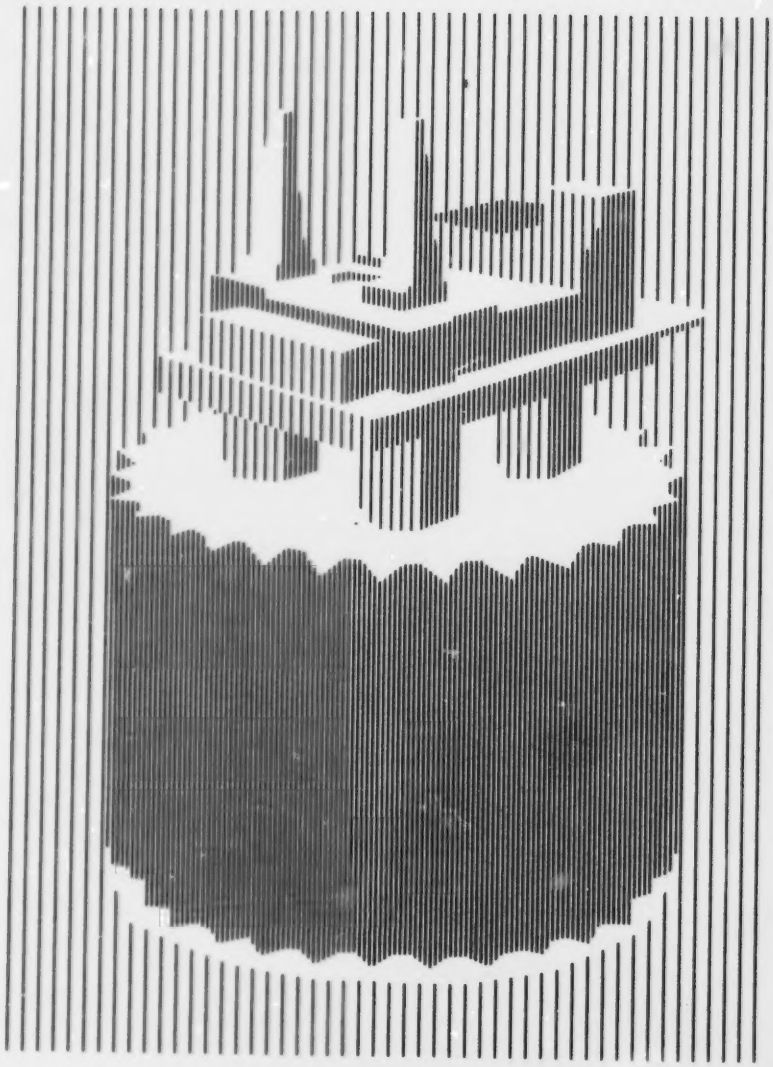
CANADA-NEWFOUNDLAND
OFFSHORE
PETROLEUM
BOARD

Decision 86.01

June, 1986
St. John's, Newfoundland



Application for Approval

Hibernia
Canada-Newfoundland
Benefits Plan

Hibernia
Development Plan

Participants

Mobil Oil Canada, Ltd.
Gulf Canada Resources Inc.
Petro-Canada Resources Inc.
Chevron Canada Resources Limited
Columbia Gas Development of Canada Ltd.

CANADA-NEWFOUNDLAND
OFFSHORE
PETROLEUM
BOARD

June 18, 1986

The Honourable Pat Carney
Minister
Department of Energy, Mines and Resources
Government of Canada
Ottawa

The Honourable William W. Marshall
Deputy Premier and
Minister Responsible for Energy
Government of Newfoundland and Labrador
St. John's

Honourable Ministers:

The Canada-Newfoundland Offshore Petroleum Board has considered the Hibernia Benefits Plan and the Hibernia Development Plan submitted on September 15, 1985 by Mobil Oil Canada Limited, on behalf of itself, Chevron Canada Ltd., Gulf Canada Resources Inc., Petro-Canada Inc. and Columbia Gas Development Ltd.

We, the undersigned members of the Board, are pleased to submit herewith our report setting forth the Board's approvals in respect thereto.

Respectfully submitted:

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Decision Summary

1.0
Introduction

This report constitutes the decision of the Canada-Newfoundland Offshore Petroleum Board (the Board) concerning the plans of Mobil Oil Canada Ltd. and its joint venture partners, (collectively referred to in this document as the Proponent) for the development of the Hibernia Oil and Gas Field. The Board was assisted in its deliberations by those groups whose work was made available for this purpose, the Hibernia Assessment Review Panel (the Panel) and departments of both federal and provincial governments, particularly the Canada Oil and Gas Lands Administration (COGLA) and the Newfoundland and Labrador Petroleum Directorate (NLPD).

Two plans were submitted for the Board's consideration, the Hibernia Benefits Plan and the Hibernia Development Plan. Both Plans were approved subject to the conditions outlined in this report.

2.0
The Hibernia Benefits Plan

Any benefits plan is, in large measure, a commitment to principles. The fundamental principles incorporated in the Atlantic Accord and its implementing legislation are designed to ensure that the resources off Newfoundland's coasts are developed in such a way that maximum benefits accrue to the Province and to Canada. In a general sense, the Board feels that the Proponent's benefits strategy does meet statutory requirements. The Board has, nevertheless, imposed specific conditions on its approval of the Hibernia Benefits Plan, and will ensure that these conditions are met.

Full and Fair Opportunity and First Consideration: The Board believes that the Proponent's stated commitment to the principle of full and fair opportunity and first consideration does meet the requirements of the legislation. However in a number of specific instances, the Board required a clarification of the Proponent's intentions. In the areas of constructing and outfitting the Gravity Base Structure (GBS), fabricating and assembling the topsides, constructing and installing the two articulated loading platforms (ALPs), building the ice clearing vessel and procuring the subsea facilities, the Board is now satisfied with the Proponent's stated position. The Board has, however, made it a condition of the approval of the Benefits Plan that the Proponent consider all reasonable alternatives to provide for maximum Canadian participation in the construction of shuttle tankers and to inform the Board of the results of these investigations.

In reviewing the Proponent's plans for development drilling and production operations, the Board has required the submission, prior to the start of production, of a training and staffing plan reflecting the maximum reasonable employment and training of Newfoundland residents.

Contractor Compliance, Technology Transfer and Supplier Development: The Board is satisfied that the Proponent will establish project management procedures that ensure contractor compliance, and support the principle of technology transfer through the encouragement of joint ventures, licensing arrangements and other appropriate mechanisms. The Proponent has also committed to ensure that, where possible, Canadian and Newfoundland business capability is considered at the design and bid packaging stages and to disseminate in a timely fashion the necessary project information to enable Canadian suppliers to prepare for participation in the project.

Project Execution: In terms of project execution, considerable discussion has been carried out on the issue of engineering activity in Newfoundland, and the Proponent has committed to provide for maximum participation by Canadian and provincial firms in design engineering activities associated with all major components of the project when it is cost effective to do so. Because of discrepencies between the cost penalty estimated by the Proponent and that estimated by the Province for assembling and outfitting the Main Support Frame (MSF) in Newfoundland rather than in another Canadian location preferred by the Proponent, the Board is requiring as a condition of the approval of the Benefits Plan, that the Proponent re-examine this issue and provide further documentation to enable the Board to evaluate the matter.

Monitoring and Reporting: The Board believes that effective monitoring and reporting will be necessary to ensure that the Benefits Plan objectives are accomplished during the execution of the project. Of particular importance to the Board in carrying out its monitoring functions is the need for timely information on contract awards. The Board has therefore required, as a condition of approval of the Plan, that the Proponent provide comprehensive listings of all major contracts or purchase orders anticipated as the project evolves. In consultation with the Proponent, the Board will then determine which of these major contracts or purchase orders will be subject to Board review. It is also a condition of approval that the Proponent provide advance notice of and information on these major contracts or purchases to enable the Board to conduct its review, with the amount of review time required to be determined by the Board in full consultation with the Proponent.

Proponent's Strategy: The Proponent has developed a Canada Benefits Strategy and the elements of that strategy are described in this report to further demonstrate the Proponent's commitment to its stated principles.

3.0
The Hibernia Development Plan

The Hibernia Development Plan sets out the Proponent's interpretation of the geology and reservoir characteristics of the Hibernia oilfield, provides estimates of hydrocarbon reserves, and describes the approach and facilities the Proponent plans to use to recover those reserves. It also includes a description of the environmental parameters governing the design of facilities.

The Board's responsibility in reviewing this plan is to ensure that hydrocarbons are produced in accordance with good oilfield practice with due regard for the efficient recovery of the resource and the prevention of waste; that the facilities are designed to operate safely throughout the expected life of the field; that a responsible approach is taken to environmental protection; and that the safety of personnel is a primary consideration.

The Board's overall response to the Development Plan has been very positive. The work submitted by the Proponent was judged to be thorough and comprehensive, and the concepts, approaches, and preliminary designs have met with general acceptance. This initial approval will be followed by more detailed analyses of plans as they evolve and subsequent approval processes for various phases of the actual work. Certifying Authorities, who are experts in this field, will be licenced by the Board to conduct detailed examinations and inspections on its behalf, and ultimately to issue a Certificate of Fitness attesting to the quality of workmanship and the suitability of the installation for its intended purpose.

Geology and Reservoir Engineering: The geological interpretations of the Proponent regarding the Hibernia and Avalon reservoirs generally concur with the Board's and those prepared by COGLA and NLPD. An exception is the interpretation of the northwest area of the Avalon Reservoir. The Proponent included this area among those having insufficient recoverable reserves to justify development, whereas NLPD's interpretation of the area is significantly more optimistic. The Board's conclusion on this matter is that the area has not yet been adequately explored, and that only through further drilling can decisions be made about its economic viability.

The Board concurs in general with the Proponent's conceptual approach to the development of the Hibernia Field, but requires the Proponent to take steps, at the initiation of development drilling, to establish the feasibility of a miscible gas flood for the Hibernia Reservoir. The Board also requires the Proponent to submit a revised development plan for the Avalon Reservoir and to give consideration, during the design process, to sizing equipment and allocating space for production facilities to accommodate additional production from the Avalon Reservoir concurrently with Hibernia Reservoir production, should there be a requirement to produce the Avalon sands prior to the year 2000, the time now envisioned by the Proponent to develop this reservoir. Further the Board requires the Proponent to file for approval a drilling schedule designed to minimize gas flaring to acceptable limits.

Environmental Parameters: The environmental parameters developed by the Proponent as design criteria for Hibernia were considered acceptable although the Board does require further studies on the estimation of extreme winds caused by mesoscale events, and additional information on design loadings for iceberg impact.

Geotechnical Engineering: The geotechnical engineering section of the Development Plan again met with general approval, although the Proponent was cautioned to design export lines and loading platforms so that they could be flushed of hydrocarbons in the event of threat of damage by icebergs and to determine the design iceberg scour depth prior to designing subsea well completions. The Proponent was also required to re-evaluate its seismic design criteria to take into account recent and ongoing studies related to seismic risk on the eastern Canadian Continental Shelf.

Production Operations: In the various operational areas, the Proponent will be required to develop and submit environmental compliance and effects monitoring plans to the Board for its approval and to provide instrumentation for structural and foundation integrity monitoring acceptable to the Certifying Authority. The Proponent was further advised to discharge oil-contaminated cuttings and treated produced water below the summer thermocline, and to submit for the Board's approval a plan for the reinjection of produced water in the event that the effects monitoring should disclose unacceptable environmental damage resulting from that source. Allowance must also be made at the design stage for facilities to treat storage displacement water should such treatment become necessary.

Subsea Facilities: Subsea installations will require the specific approval of the Board, and the Proponent will be required to support the application for approval at the time it intends to proceed with these installations. The Proponent has been advised, however, that all subsea facilities must be designed such that they are capable of being recovered or removed to restore the site to a fishable condition after abandonment, and that the GBS must be designed such that it could be removed if the Authorities of the day so require.

Fisheries Exclusion Zone and Environmental Protection: Prior to the start of production, the Board will establish an exclusion zone around the offshore installation following consultations with the fishing industry, the Department of Fisheries and Oceans and the Proponent. Finally, the Board has required the Proponent to prepare for its approval an Environmental Protection Plan describing its systems, procedures, and plans for environmental protection, and to update the plan periodically as the project evolves.

1.0
Introduction

1.1
Introduction

Proponents of development projects are required, under the Atlantic Accord and the 1986 Implementing Legislation, to obtain approval of development plans for projects offshore Newfoundland and Labrador from the Canada-Newfoundland Offshore Petroleum Board (the Board). Before approving a development plan, the Board must have approved a Canada-Newfoundland benefits plan.

This report (the Decision Report) constitutes the Board's decision with respect to both the Hibernia Benefits Plan and the Hibernia Development Plan and sets forth the terms and conditions of the Board's approval.

1.2
The Board's Authority

On February 11, 1985 the Government of Canada and the Government of Newfoundland and Labrador signed an agreement known as the Atlantic Accord covering the joint management of the oil and gas resources offshore Newfoundland and Labrador and the sharing of revenues from exploitation of these resources. Under the Atlantic Accord, a substantial part of the joint management is the responsibility of the Board. On February 7, 1986, *Bill #C94* was introduced in the Parliament of Canada to implement the Atlantic Accord Agreement; on the same day *Bill #59* was introduced in the House of Assembly of the Province of Newfoundland to implement the Atlantic Accord Agreement. *Bill #59* was subsequently re-introduced in the House as *Bill #1* on March 18, 1986.

This implementing legislation has not yet been passed by the respective legislative assemblies. Notwithstanding the status of the legislation, the Board has been instructed by the Minister of Energy, Mines and Resources of Canada (the Federal Minister) and the Minister Responsible for Energy for the Province of Newfoundland (the Provincial Minister) to proceed with its review and Decision Report respecting the Hibernia Project under the procedures contained in the implementing legislation.

1.3
The Approval Procedure

Subject to certain rights retained by the Federal Minister and the Provincial Minister under the implementing legislation, the Board is given wide responsibility for the management of the exploration and development of the offshore areas of the Province of Newfoundland and Labrador.

With respect to a Canada-Newfoundland benefits plan under the implementing legislation, the Board is required to consult with the Federal and Provincial Ministers in reaching its decision. Furthermore, the Ministers may issue to the Board joint written directives in relation to a Canada/Newfoundland benefits plan and any of the provisions thereof. Subject to any directives so issued, the Board, pursuant to Section 45 of the proposed *Canada-Newfoundland Atlantic Accord Implementation Act* and Section 45 of the proposed *Canada-Newfoundland Atlantic Accord Implementation (Newfoundland) Act*, may approve a Canada/Newfoundland benefits plan.

Pursuant to section 134 of both the above-noted statutes, the Board may approve a development plan subject to approval by the Federal Minister and the Provincial Minister, of certain aspects including scope, timing, environmental factors and the production system to be used.

1.4
The History of the Hibernia Project

During the 1960's, Mobil Oil Canada, Ltd. (75%) and Gulf Canada Resources Inc. (25%) acquired under federal permits approximately 2.6 million hectares of offshore acreage located primarily on the Grand Banks. The federal permits required a minimum exploration effort to retain their tenure in good standing and were subject to expiry on January 15, 1978.

Provisions were contained in the *Canada Oil and Gas Lands Regulations* dealing exclusively with the expiration of federal permits. These provisions enabled a permittee to acquire a Special Renewal Permit (SRP) or an Oil & Gas Lease (OGL) upon expiration of the term. Documentation supporting the applicant's Canadian Participation Rate (CPR) was a requirement for the SRP.

When Mobil and Gulf applied for SRPs covering their original federal permit acreage and the CPR was determined, Petro-Canada was entitled to acquire a 25 percent participating share in all lands. On January 15, 1978, SRPs were issued for a three-year term from that date, at the following working interest shares: Mobil Oil Canada Ltd. (56.25%); Gulf Canada Resources Inc. (18.75%); Petro-Canada Inc. (25%).

During 1978, farmout discussions were conducted among the SRP participants, Chevron Canada and Columbia Gas Development. A farmout arrangement was consummated in February 1979. The farmout agreement covering a 212,468 hectare block, called for the drilling of one exploration well. On May 27, 1979 Chevron Canada spudded the discovery well, Chevron et al Hibernia P-15. Upon completion of this well, the interest participation in the block which contains the Hibernia Field was:

Participant	%Interest
Mobil Oil Canada, Ltd.	28.12500
Gulf Canada Corporation	25.00000
Petro-Canada Inc.	25.00000
Chevron Canada Resources Limited	16.40625
Columbia Gas Development of Canada Ltd.	5.46875

The same interests prevail at the time of writing this report.

The *Canada Oil & Gas Act (COGA)* was promulgated on March 5, 1982 as part of the *National Energy Program*. COGA provided for the issuance of Exploration Agreements (EAs) or provisional leases on all previously held permits or special renewal permits.

For the purpose of negotiating Exploration Agreements, the area held by Mobil and partners under the SRP comprising the original farmout block acreage, was separated into two parts. The part containing the Hibernia Significant Discovery Area (SDA) was negotiated under EA 195. This exploration agreement covering 36,436 hectares was issued for a 29 month period, January 15, 1983 — June 15, 1985, and required a two-well program consisting of one delineation and one exploration well. The program commitment was satisfied by drilling Mobil et al Hibernia B-27 and Mobil et al Mara M-54.

On October 2, 1985, the area comprising the Hibernia SDA was officially declared in *The Canada Gazette*. The areal extent was 18,745 hectares, a reduction of 17,691 hectares from that included in the original EA 195. This reduction was the result of the drilling of Mara M-54 which did not support the extension of hydrocarbon bearing Hibernia sands to that location.

1.5
Information Considered by the Board

Mobil Oil Canada Ltd. (Mobil) as operator of the Hibernia Project filed the Hibernia Development Plan (the Development Plan) and the Hibernia Benefits Plan (the Benefits Plan) on September 15, 1985 on behalf of itself and the other participants in the Hibernia joint venture (collectively called the Proponent). These documents in combination constitute the detailed application of the group for approval of the project.

The Development Plan and the Benefits Plan were filed with the Canada Oil and Gas Lands Administration (COGLA) and the Newfoundland and Labrador Petroleum Directorate (NLPD). Following the formation of the Board, with the appointment of the first Board members effective December 1, 1985, the documents were referred to the Board by COGLA and NLPD.

1.5.1
The Hibernia Benefits Plan

The Benefits Plan document is a statement of the Proponent's objectives and its strategy to optimize benefits to Canada and Newfoundland from the project. It provides information on the Proponent's expectations of the industrial and employment benefits to Canada and Newfoundland. It also indicates that Mobil will provide an appropriate internal organization to deal with the Board on benefits matters.

Additional documents and letters were submitted to the Board by the Proponent in response to specific requests for information concerning the Proponent's plans for procurement of equipment, materials, engineering services and sites for the fabrication and assembly of various parts of the system. Some of these documents modified and expanded on the Benefits Plan as originally filed.

1.5.2 The Hibernia Development Plan

The Development Plan consists of two volumes which describe in detail the Hibernia project including descriptions of the facilities, the schedule for construction and development drilling and the production forecast under the following headings:

- *Volume I*
  - Chapter 1 — Project Overview
  - Chapter 2 — Geology
  - Chapter 3 — Reservoir Engineering
  - Chapter 4 — Physical Environment
  - Chapter 5 — Geotechnical Engineering
- *Volume II*
  - Chapter 6 — Production and Transportation Systems
  - Chapter 7 — Construction and Installation
  - Chapter 8 — Development Drilling, Completion and Workover
  - Chapter 9 — Production Operations and Maintenance
  - Chapter 10— Development Costs

1.5.3
The Environmental Impact Statement

On May 15, 1985 Mobil filed an Environmental Impact Statement (EIS) with COGLA and NLPD describing two alternative modes of development. This statement included the following volumes:

- *Volume I* — Summary
- *Volume II* — Project Description
- *Volume IIIa* — Biophysical Assessment
- *Volume IIIb* — Biophysical Assessment
- *Volume IV* — Socio-Economic Assessment

In August 1985, Mobil filed a further document entitled EIS Update, August 15, 1985 selecting a fixed production system over a floating production system as the preferred mode of development. Subsequently, in September 1985, Mobil filed a report entitled EIS Supplement, September 15, 1985.

1.5.4
The Hibernia Environmental Assessment Panel Report

Prior to the formation of the Board, the Governments of Canada and Newfoundland established the Hibernia Environmental Assessment Panel (the Panel) to make recommendations on the terms and conditions under which the Hibernia development could proceed in a safe and environmentally acceptable manner. The information filed in the EIS by the Proponent was considered in detail by the Panel. Following extensive input from the public, the Proponent, various government departments, community and trade associations and other interested parties, the Panel released its report in early January 1986. Most of the findings and recommendations in the Panel's report fall within the Board's jurisdiction and were considered by the Board in reaching its decisions. Some of the Panel's recommendations pertained to the Development Plan and others to the Benefits Plan and the Board has separated them accordingly.

The recommendations concerning employment, technology transfer and supply of goods and services form the basis for much of the Board's Benefits Plan Decision covered in Part 2. Most of the Panel's recommendations on socio-economic matters fall outside the Board's direct responsiblity, but for the sake of completeness and emphasis they are discussed in Part 2, Section 2.4. The recommendations concerning environmental matters and safety are included in various sections of Part 3 of this report. Appendix A lists the Panel's recommendations.

A number of the Panel's recommendations were directed to other government departments or dealt with matters which are not within the Board's jurisdiction and have, therefore, not been responded to in this report, (recommendations #32, 36 and 37). Other issues such as local hiring, union membership and utilization of the Offshore Development Fund and the Environmental Studies Revolving Fund are principally the responsibility of other agencies and it is not appropriate for the Board to comment on them, (recommendatins #9, 3, 4, 17, 18, 50 and 47). The other group of recommendations which the Board has not discussed in this report are those related to the process of public hearings, (recommendations #44, 45 and 46). Many of the terms and conditions of such hearings are stated in the Atlantic Accord implementing legislation and are therefore not germane to this decision.

1.5.5
COGLA and NLPD Reports

The Board has relied extensively on evaluation work done by COGLA and NLPD in reaching its decision. Both organizations carried out substantial studies on the geological and reservoir aspects of the Hibernia Field during its delineation stage.

These studies and others concerning the development were made available to the Board and its staff. Upon receipt of the Development Plan, a joint committee of COGLA and NLPD officials (the Committee) was formed to evaluate the development proposals. The Committee's findings have been used extensively by the Board.

The comprehensive and thorough work done by the staff of COGLA and NLPD made it possible for the Board to prepare its decision within the time available.

1.5.6
Meetings and Other Sources of Information

The Board and its staff participated in several meetings with representatives of the Proponent. Discussions were held with officials of COGLA, NLPD, the provincial departments of Development and Tourism, Finance, and Career Development and Advanced Studies, the federal department of Regional and Industrial Expansion and the Canada Employment and Immigration Commission. The information and comments received through these meetings and discussions were of great assistance to the Board in reaching its decisions.

1.6
Confidentiality of the Submissions

The Benefits Plan and Development Plan documents of the Proponent were filed with the provision that they be held in confidence. The following statement appeared extensively throughout these documents:

> "This is financial, commercial, scientific or technical information which: (a) is confidential under the *Access to Information Act* and is not to be released or made public except as provided in that Act, and (b) if disclosed would affect either the continued access to such information or would affect the competitive position of Mobil Oil Canada, Ltd. and joint venture participants or result in undue financial loss thereto and access thereto should be refused pursuant to the *Freedom of Information Act (Newfoundland)*".

The Board urged the Proponent to release all the documents filed in relation to the project as public documents in order that the Board's decisions and any requirements related thereto, could be clearly understood by all interested parties. The Proponent, however, took the position that much of the information filed was proprietary in nature, was based on research and development done by the Proponent, was commercially sensitive or might have an adverse impact on competitive bidding for contracts. As a result, it has been necessary for the Board to paraphrase extensively the Proponent's statements and positions on various issues.

With respect to the Development Plan, the Proponent has provided an abridged version of Chapter One of its Development Plan, entitled Development Plan Overview, which it considered suitable for public release. This document has been reproduced in its entirety as Appendix D of this report. In addition, certain other information drawn from the text of the Hibernia Development Plan and from supplementary correspondence related to the Hibernia Benefits Plan is quoted in various parts of the Decision Report. The reproduction of this information has been specifically authorized by the Proponent.

2.0 The Hibernia Benefits Plan

2.1
Introduction

The Hibernia Benefits Plan is approved by the Board subject to the conditions noted in this report.

The Plan, including various supplementary documents, sets out the Proponent's intentions and expectations of how the economic benefits associated with the development of the Hibernia oil field will accrue to Canada in general and to Newfoundland and Labrador in particular.

While reviewing the Plan and its associated documents, the Board held a number of discussions with the Proponent for the purpose of clarifying and refining various elements of the Plan. The Board also took into account the recommendations of the Hibernia Environmental Assessment Panel as well as the comments of a number of federal and provincial government departments and agencies, including: the Canada Oil and Gas Lands Administration (COGLA), the Department of Regional Industrial Expansion (DRIE), the Canada Employment and Immigration Commission (CEIC), the Newfoundland and Labrador Petroleum Directorate (NLPD), the Department of Development and Tourism (DODT) and the Department of Career Development and Advanced Studies (DCDAS).

The Board's primary purpose in reviewing the Hibernia Benefits Plan was to ensure that it adequately met the requirements of the implementing legislation. This legislation requires, among other things, that a benefits plan contain provisions intended to:

(i) provide for the employment of Canadians and, in particular, members of the labour force of the province and provide manufacturers, consultants, contractors and service companies in the province and other parts of Canada with full and fair opportunity to participate on a competitive basis in the supply of goods and services used in any proposed work or activity referred to in the benefits plan;

(ii) ensure that, consistent with the Canadian Charter of Rights and Freedoms, individuals resident in the province shall be given first consideration for training and employment; and,

(iii) ensure that first consideration shall be given to services provided from within the province and to goods manufactured in the province, where those services and goods are competitive in terms of fair market price, quality and delivery.

The Board reviewed the Hibernia Benefits Plan against these criteria. Its conclusions and conditions related to benefits principles, specific project execution issues as well as monitoring and reporting are contained in this Part of the Decision Report. A number of socio-economic issues raised by the Panel were also considered by the Board and a review was carried out of the Proponent's position and the Panel's recommendations. These issues are discussed in detail in Section 2.4.

The Board considered a number of regulatory management options for ensuring that the greatest possible economic benefit accures to both Newfoundland and Labrador and the rest of Canada. It was the decision of the Board that the most effective approach would be to encourage the commitment of the Proponent to a series of basic principles. The implementation of these basic principles would, in the Board's opinion, be more effective than attempting to negotiate specific requirements for the multitude of elements of which the project will consist. The Board will monitor the project, as it proceeds, to ensure that the Proponent complies with the commitments.

The development and implementation of a benefits plan is, because of the nature of the subject matter, an evolutionary process. The Board has found the Proponent willing to amend its positions to comply with regulatory requirements and to respond positively to issues of concern. It is the Board's expectation that the Proponent's demonstrated responsiveness in the area of benefits will continue through the duration of the project.

HIBERNIA BENEFITS PLAN DECISION

It is the decision of the Board that the Hibernia Benefits Plan is approved, subject to the conditions noted in this Benefits Plan Decision.

2.2 Benefits Principles

This section of the report reviews the Proponent's Benefits Plan as it relates to commitment to the principles of full and fair opportunity and first consideration, contractor compliance, technology transfer and supplier development. The findings of the Panel are discussed and the Board's requirements are explained.

2.2.1 Full and Fair Opportunity and First Consideration

Full and fair opportunity for Canadians, with first consideration for Newfoundlanders, to participate in the provision of goods, services and employment is a fundamental provision of the Atlantic Accord and its implementating legislation.

The objectives stated in the Proponent's Benefits Plan are to provide Canadian suppliers with a full and fair opportunity to bid on an internationally competitive basis and to evaluate bids on the criteria of best value, with best value meaning the best combination of price, technical ability, quality, and assurance of supply, delivery and service. Where bids are equally competitive on a best value basis, the Proponent's objective is to give preference to companies which provide services or manufacture goods in Canada.

The Proponent has also expressed in its Benefits Plan, a number of employment-related goals. Specifically, the Proponent's goals include maximizing long-term job opportunities for qualified Canadians and Newfoundlanders and disseminating information on its labour demands and project-related job descriptions to governments, industry and the public.

The Panel recommended that, as a condition of development approval, a plan for Canadian and Newfoundland industrial benefits be approved and monitored (Panel recommendation #8); that government establish, and the Proponent be required to meet, realistic Newfoundland employment goals with emphasis on production phase employment (Panel recommendation #1); that the Proponent regularly provide government with detailed, updated lists of job opportunities as planning of the project evolves (Panel recommendation #2); and that a comprehensive training strategy, including both institutional and on-site components, be developed for the project concentrating on areas of long-term benefit. (Panel recommendation #5).

While the Board's mandate is to ensure that full employment opportunity is given to Canadians and especially to Newfoundlanders, the Board does not support the establishment of specific employment goals, expressed in either absolute or percentage terms, for this project. In the Board's view, maximum short-term and long-term employment participation can be achieved most effectively through ongoing project monitoring and consultation with the Proponent.

The Proponent's initial commitments in its Benefits Plan regarding first consideration addressed the aspect of employment; however, no commitment was expressed to offer first consideration to Newfoundland based suppliers and manufacturers. Subsequent documentation received from the Proponent confirmed the Proponent's commitment to the entire principle of full and fair opportunity and first consideration. The Proponent has committed to:

> "Utilize, to the extent practical and cost effective, the principle of first consideration to Newfoundland and Canada in procurement, contracting and employment policies for the project including the construction, development and operating phases. Provide Newfoundland industry and other Canadian industry with full, fair and timely opportunities to participate in the supply of goods and services on a competitive basis in terms of price, quality and delivery."
>
> (Hibernia Benefits Plan (HBP) Supplementary Correspondence)

The Board believes that this commitment to the principle of full and fair opportunity and first consideration adequately meets the requirements of the legislation and is satisfied that it demonstrates the Proponent's intention to comply with the requirements.

While this commitment ensures the application of this principle to the overall project, there were a number of specific aspects where the Board felt that the opportunity for Newfoundland and other Canadian participation should be more clearly defined. In the following areas, the Board sought, and received, from the Proponent commitment to the application of the principle of full and fair opportunity and first consideration:

- Gravity Base Structure;
- Topsides Facilities;
- Articulated Loading Platform;
- Shuttle Tankers;
- Ice Clearing Vessel;
- Subsea Facilities; and
- Development Drilling and Producing Operations.

These major production system components are illustrated in Figure 2-1.

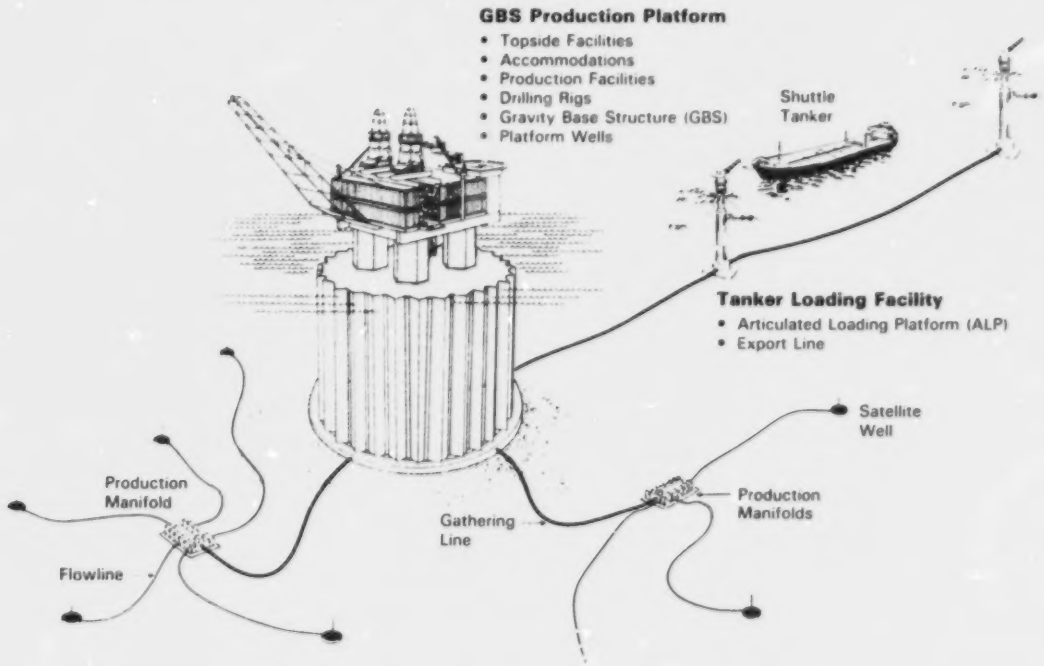
2.2.1.1
Gravity Base Structure (GBS)
Construction and outfitting of the Hibernia GBS will be a very large 'turnkey' contract requiring in the order of 3,500 person-years of employment concentrated largely over a three year construction period, 1987-1989. Figure 2-2 illustrates the construction sequence for the GBS platform.

The Proponent has projected an estimated Canadian content of 80 to 90 percent with Newfoundland content estimated at 60 to 70 percent, based on the proposed Placentia Bay construction and outfitting site. The Proponent has proposed prefabricating and preassembling components and packages for mechanical outfitting at a second, unspecified site in Newfoundland, in parallel with the main construction effort.

The Proponent has also proposed to procure the vast majority of bulk materials (cement and reinforcing steel) in Canada, but stated that materials such as J-tubes, large motors and valves, and some alloy reinforcing steel are not available in Canada and therefore will be sourced internationally. Tug fleet services will also be foreign-sourced.

Because of the magnitude of the GBS construction and outfitting project, the Board sought from the Proponent commitments in the areas of achieving proposed content estimates, access to the outfitting packages and sourcing of equipment and bulk materials in Canada.

Figure 2-1
Production System Components



Source: Hibernia Development Plan (HDP), Figure 1.6-1

The Proponent addressed these items by committing to:

> "• maximize efforts to achieve the overall Canadian and Newfoundland contents estimated for construction of the gravity base structure . . .;
> • provide full and fair opportunity for Newfoundland fabricators to participate in fabrication of mechanical outfitting packages for the gravity base structure; and
> • maximize efforts to source equipment and bulk materials in Canada"
> (HBP, Supplementary Correspondence)

The Board is satisfied that the Proponent's responses on these matters demonstrate an intention to maximize benefits to Canada and Newfoundland in this aspect of the project.

2.2.1.2
Topsides Fabrication and Assembly

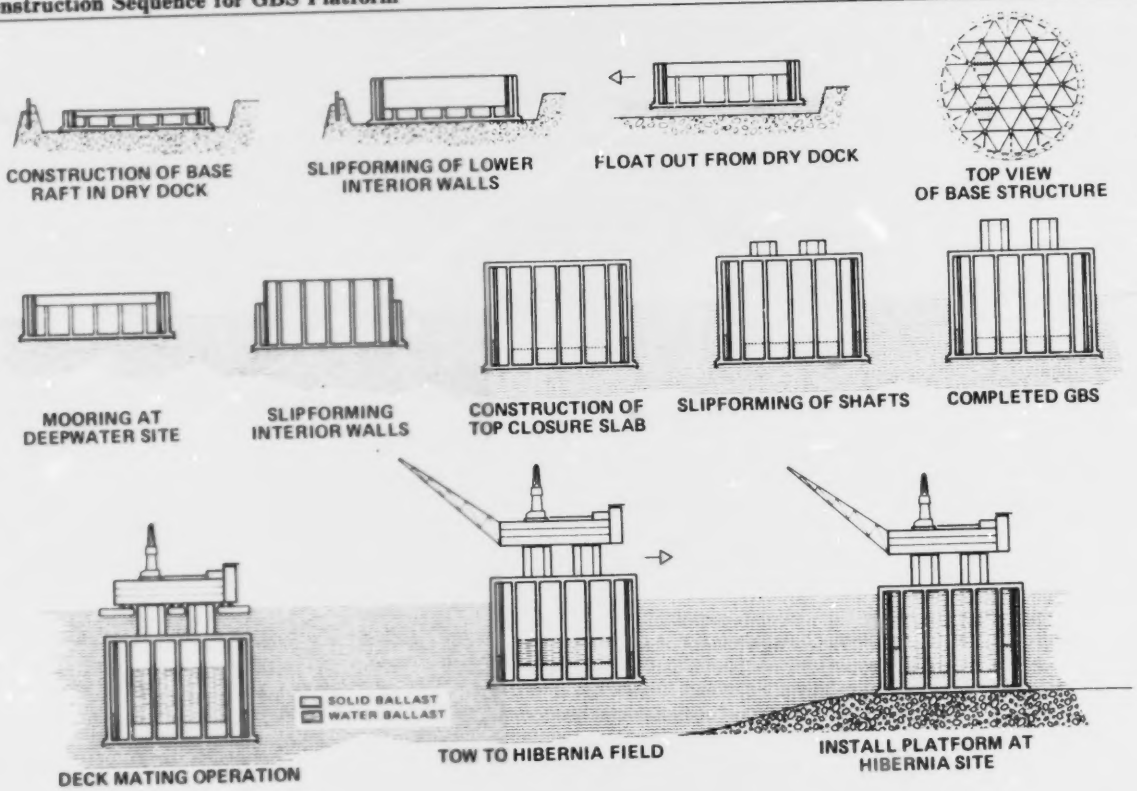
Fabrication and assembly of the GBS topsides represents in the order of 5,000 person-years of fabrication and construction activity over the 1987-1992 time frame. This accounts for approximately 50 percent of the project's total fabrication and construction requirements, excluding the shuttle tankers.

Figure 2-3 illustrates the assembly sequence for topside facilities, and the table below provides the Proponent's estimates of labour requirements associated with this component of the work.

	Person-Years
Deck Fabrication	415
Modules & Preassemblies	2,650
MSF Assembly & Hook-up	815
Module Hook-up	700
Platform Mating & Hook-up	705
	5,285

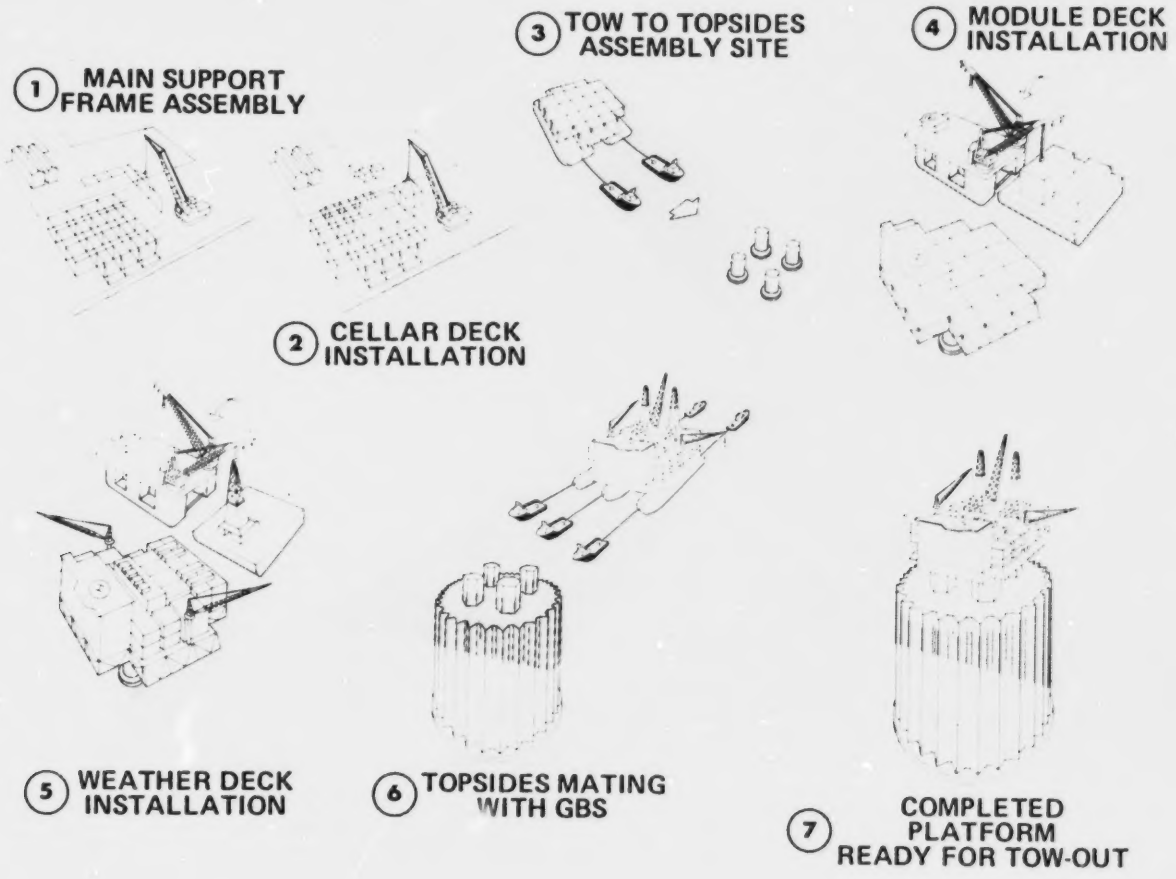
(Source: HBP, Supplementary Correspondence)

Figure 2-2
Construction Sequence for GBS Platform



Source: HDP, Figure 1.7-2

Figure 2-3
Assembly Sequence for Topside Facilities


1 MAIN SUPPORT FRAME ASSEMBLY
2 CELLAR DECK INSTALLATION
3 TOW TO TOPSIDES ASSEMBLY SITE
4 MODULE DECK INSTALLATION
5 WEATHER DECK INSTALLATION
6 TOPSIDES MATING WITH GBS
7 COMPLETED PLATFORM READY FOR TOW-OUT

Source: HDP, Figure 1.7-3

The Proponent's proposed execution plan for topsides fabrication and assembly is based on its assessment of Canadian yard and shop capacity and is summarized as follows:

- Fabrication of 3 of the 4 major deck sections at a number of unspecified foreign locations with one major deck section, transition rings and smaller infill sections fabricated at one or more unspecified Canadian locations.
- Fabrication of MSF preassemblies at a number of unspecified Newfoundland and other Canadian locations.
- Assembly of the MSF and cellar deck installation at an unspecified eastern Canadian location outside the province.
- Fabrication of 50 percent of the topside modules at a number of unspecified foreign yards with the remaining modules sourced in Canada, including a possible 5 to 10 percent in Newfoundland.
- Sourcing of bulk material and equipment in Canada where available. Typical examples of bulk material and equipment indicated by the Proponent that are not available in Canada for this project include gas turbines, gas compressors, primary steel, large motors, large valves, high tensile steel, large pumps and most instrument and electrical cable.
- International fabrication of the two large GBS mounted drilling rigs. The Proponent contends that Canadian fabricators cannot competitively meet these requirements.
- Module installation and hook-up at a greenfield facility adjacent to the GBS construction site in Newfoundland.
- Platform mating and hook-up activities at a deepwater site in Newfoundland and final hook-up at the Hibernia site.

The Board does not accept the Proponent's contention that the bulk materials and equipment listed above are not available in Canada. However, the Proponent has committed to:

> "advising the Board respecting any required foreign sourcing of major equipment or bulk materials and the rationale supporting the requirement to foreign source."
>
> (HBP, Supplementary Correspondence)

The Proponent indicated that all major project fabrication requirements will be subject to international competitive bidding, and stated that Canadian yards will require improvements in management and technical resources and, in many instances, upgraded facilities to meet offshore standards.

Based on existing infrastructure and capacity, and its proposed execution plan, the Proponent estimated Canadian content for the topsides component of the project at 50 to 60 percent, and Newfoundland content at 10 to 20 percent.

As previously stated, the topsides fabrication and assembly account for approximately 50 percent of the entire project's fabrication and construction requirements. Therefore, the Board sought from the Proponent a commitment to use its best efforts to meet its Canadian and Newfoundland content estimates for this portion of the project. In response, the Proponent committed to:

> "maximize efforts to achieve the overall Canadian and Newfoundland contents estimated for construction of . . . the topsides . . . "
>
> (HBP, Supplementary Correspondence)

The Board accepts the Proponent's commitment to meeting the contents estimates as quoted, and it believes that the Proponent may be able to achieve a higher Canadian content and a greater Newfoundland participation in topsides fabrication and assembly than was indicated.

2.2.1.3
Articulated Loading Platforms (ALPs)
Construction and installation of the two ALPs and associated crude export lines are scheduled to take place during 1989-1991. These activities will require an estimated 650 person-years of employment.

The Proponent proposed fabricating all major ALP components (i.e. bases, columns and rotating heads) outside Canada due to the expected lack of yard capacity in eastern Canada. A preference was indicated to fabricate the major components of the ALPs in a single location to meet the stringent tolerance requirements. Final assembly of the ALPs will likely take place in Canada, possibly at a Newfoundland location. Figure 2-4 illustrates the assembly sequence for the ALPs.

Given the Proponent's statements that lack of yard capacity may necessitate fabricating the ALP components outside Canada, but the fact that the GBS drydock facility in Newfoundland will probably be available at that time, the Board requested the Proponent to ensure that Canadian yards and particularly the GBS drydock be considered for the ALP construction.

In response the Proponent committed to:

> "provide a full and fair opportunity for Canadian yards, including the gravity base construction site, to participate in fabrication and assembly activities for the articulated loading platforms."

The Board is satisfied with the Proponent's assurance that Canadian and Newfoundland yards will be considered for this work.

2.2.1.4
Shuttle Tankers
The Proponent has indicated that three purpose-built 120,000 dwt shuttle tankers will be required to deliver produced crude to market. Total employment requirements to construct these vessels are estimated at 3,000 person-years. Because of size limitations in Canadian shipyards these vessels cannot presently be fabricated in Canada.

The Proponent has indicated that only one shipyard located on Canada's East Coast could be practically expanded to build 120,000 dwt vessels. However, the Proponent has also indicated significant cost and schedule penalties for construction of shuttle tankers in Canada versus construction in internationally competitive shipyards. The Proponent has estimated that a such large Canadian vessel would be approximately 60 percent more costly than an equivalent vessel acquired through international bidding, and would take six to twelve months longer to complete.

The Proponent has investigated the feasibility of utilizing a fleet of five 80,000 dwt tankers which could yield a delivery efficiency similar to the 120,000 dwt fleet. However, the Proponent has eliminated this option because of higher capital and fleet operating costs.

While the Board agrees with the general position of the Proponent, there are a number of alternatives to increase Canadian content that might be considered. These include the possibilities of final outfitting of the vessels in Canada and the modification of existing vessels.

Canadian yards have the capacity to execute this reduced scope of work for vessels up to 150,000 dwt. The procuring of steel and equipment from Canadian sources also represents opportunities worthy of further investigation.

The Board feels that while ensuring full and fair access for Canadian shipyards to bid on this work would certainly conform to the principle of full and fair opportunity, this alone does not satisfy the Board that all alternatives for participation would be explored.

CONDITION 1

It is a condition of the approval of the Hibernia Benefits Plan that the Proponent consider all reasonable alternatives to provide for maximum Canadian participation in shuttle tanker construction, and inform the Board of the results of these investigations.

2.2.1.5
Ice Clearing Vessel

One purpose-built ice clearing vessel will be required to support production operations at Hibernia. Construction employment is estimated at 450 person-years. The Proponent has projected that a high Canadian and Newfoundland content can be achieved in the fabrication of this vessel. Preliminary estimates indicate 75 percent Canadian with 50 percent Newfoundland content.

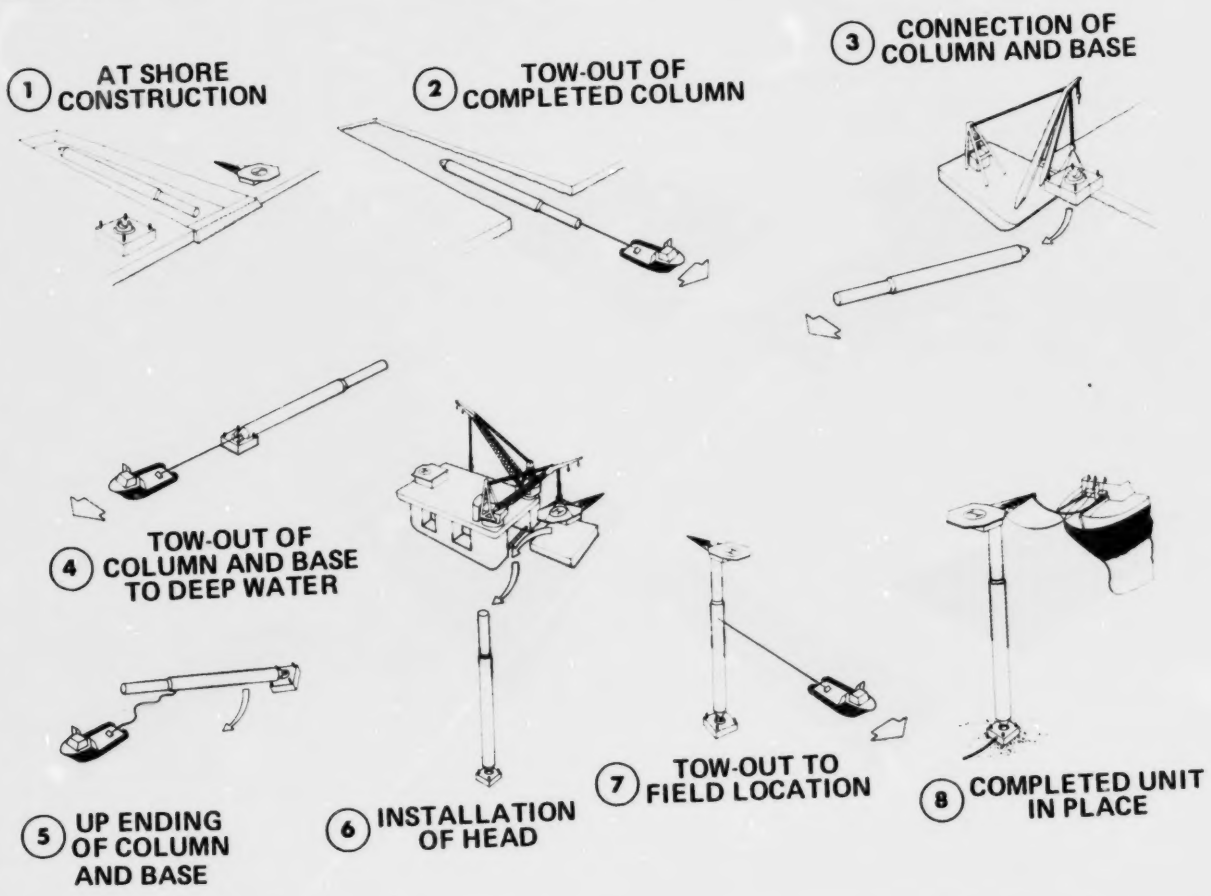
The potential opportunities available to both Canada and Newfoundland as indicated by the Proponent's projected content levels prompted the Board to seek a firm commitment from the Proponent to use its best efforts to achieve these content levels.

In response, the Proponent has committed to:

> "maximize efforts to achieve the overall Canadian and Newfoundland contents estimated for construction of . . . the ice clearing support vessel."
> (HBP, Supplementary Correspondence)

The Board is satisfied with the Proponent's significant commitment to this matter.

Figure 2-4
Assembly Sequence for Articulated Loading Platform


1 AT SHORE CONSTRUCTION
2 TOW-OUT OF COMPLETED COLUMN
3 CONNECTION OF COLUMN AND BASE
4 TOW-OUT OF COLUMN AND BASE TO DEEP WATER
5 UP ENDING OF COLUMN AND BASE
6 INSTALLATION OF HEAD
7 TOW-OUT TO FIELD LOCATION
8 COMPLETED UNIT IN PLACE

Source: HDP, Figure 7.4-1

2.2.1.6
Subsea Facilities
The Hibernia Field consists of six reservoirs, of which the two most important are the Hibernia and Avalon Reservoirs. The Proponent plans a full development of the Hibernia Reservoir and a possible partial development of the Avalon Reservoir as Hibernia Reservoir production begins to decline around the year 2000. While development of the Hibernia Reservoir will be accomplished primarily from wells drilled from the fixed platform, the Avalon Reservoir will require extensive subsea development.

The main components of the subsea facilities are the production manifolds, headers and intrafield pipelines. The Proponent estimated that fabrication, assembly and installation of the manifolds and headers will generate 225 person-years of work with 150 person-years based in Canada, of which 100 person-years will be in Newfoundland. The Proponent also estimated that flowline preparation and installation activities will generate a further 625 person-years of activity in the province.

The Proponent proposed to source wellhead equipment and line pipe outside of Canada. The Proponent also proposed to use foreign vessels to install intrafield pipelines.

Based on its construction plan, the Proponent estimated an overall Canadian content of 55 to 65 percent with Newfoundland content estimated at 25 to 35 percent for the subsea component of the project.

Given the extensive lead time available for this particular portion of the project, and the potential opportunities which may be available to Canada and Newfoundland, the Board requested that the Proponent address this phase of the Hibernia development under a supplementary document at a later date.

In response the Proponent committed to:

> "Submit for the Board's approval, a Canada/Newfoundland Benefits Plan prior to proceeding with Avalon reservoir subsea systems development."
>
> (HBP, Supplementary Correspondence)

2.2.1.7
Development Drilling and Production Operations
St. John's, Newfoundland was identified by the Proponent as the preferred location for a supply base to support both the development drilling and production phases of the Project.

The Proponent estimated that the development drilling phase of the project will generate 1,650 person-years of employment related to platform and semi-submersible drilling activities during the period 1992 to 2002. It was estimated that production operations, with an annual employment level of 1,090 persons, will generate a further 16,350 person-years of employment during the life of the project. The Proponent projected that 100 percent of these positions will be filled by Newfoundland residents. The Proponent also indicated that it will ensure that the maximum number of long-term job opportunities will be made available to qualified Newfoundlanders and other qualified Canadians.

The Panel recommended that employment training strategy and goals concentrate on those areas of greatest long-term benefit with emphasis on production phase employment opportunities. (Panel recommendations #1, 5).

It is the firm intention of the Board to enforce the spirit and intent of the legislative requirement that, subject to the *Canadian Charter of Rights and Freedoms*, first consideration be given to residents of the province for training and employment related to the project.

The Board, while agreeing with and supporting the Proponent's contention that the facility must be staffed by fully-qualified persons, requires assurance that the legislative requirements will be met during the production phase. The Board recognizes that, initially, a significant number of the specialized positions related to the production phase of the project will likely have to be filled by persons who were not residents of Newfoundland, nor, perhaps, of Canada, before their employment. However, the Board requires that Newfoundland residents be given first consideration for training to eventually fill these positions and will require the Proponent to indicate how this will be accomplished.

CONDITION 2

It is a condition of the approval of the Hibernia Benefits Plan that, prior to the start of production, the Proponent submit a training and staffing plan reflecting the maximum reasonable employment and training of residents of Newfoundland.

2.2.2
Contractor Compliance

Contractor compliance means that all contractors involved in the project must comply with the benefits commitments made by the Proponent in its Benefits Plan.

The Panel has recommended that the Benefits Plan provide for adherence to the Plan by the Proponent's subcontractors. (Panel recommendation #8).

The Benefits Plan is that of the Proponent, not of its contractors, yet the project will be executed largely by contractors under the Proponent's supervision. Therefore, unless these contractors are required to comply with the Proponent's stated commitments, parts of the project could be completed without regard for the principles of full and fair opportunity and first consideration. Therefore, the Board requested that the Proponent consider this principle in terms of a firm commitment and to consider procedures to ensure compliance.

In response the Proponent committed to:

> "establish project management procedures to ensure contractors comply with its committed principles."
>
> (HBP, Supplementary Correspondence)

The Board accepts and welcomes the Proponent's firm and decisive commitment to this principle.

2.2.3
Technology Transfer

The objective of technology transfer is to ensure that Canadian and Newfoundland businesses will have the opportunity to gain experience or 'know-how' and to absorb new technology through appropriate exposure to foreign expertise in strategic aspects of the project. This exposure will assist in developing a Canadian capability which will allow Canadian businesses to compete more successfully in future offshore projects.

The Proponent's stated objectives in this area are to encourage the enhancement of Canadian technology, expertise and facilities and to support technology transfer to interested and capable Newfoundland and other Canadian contractors by supporting the formation of joint ventures with experienced international contractors.

The Panel recommended that technology transfer be emphasized in the Proponent's Benefits Plan and be closely monitored. (Panel recommendation #8).

The Board recognizes the need for foreign technology to execute this initial offshore project successfully. The Board also recognizes the importance of transferring this technology to Canadians for application to future offshore developments.

After discussing this principle with the Board, the Proponent has committed to:

> "support the principle of technology transfer and support formation of joint ventures, licensing arrangements and other appropriate mechanisms."
>
> (HBP, Supplementary Correspondence)

The Board is satisfied with the Proponent's commitment to this principle, which is intended to ensure long-term benefits from this project.

2.2.4
Supplier Development

The objective of supplier development is to develop reliable domestic sources of goods and services including management, technical and engineering support. The Proponent's objective, as recorded in its Benefits Plan, is to encourage the development of internationally competitive Canadian sources of supply, whenever possible.

The Proponent committed to provide information, to encourage supplier initiatives to participate in the project, and to the extent that it is practical and cost effective, to design, construct and operate the project facilities such that maximum benefits accrue to local Newfoundland and other Canadian areas directly involved with project activities.

The Panel recommended a requirement for ongoing consultation among the Proponent, government and industry to ensure awareness of opportunities arising from the project. (Panel recommendation #8). Additionally, the Panel recommended that appropriate training and assistance be provided to small business. (Panel recommendation #10).

The Proponent's adherence to the overall principles discussed above should assist in the development of Canadian suppliers as all the principles are supportive of, and directly affect the achievement of this objective. However, the manner in which the Proponent executes this project will also have a direct impact on supplier development, particularly in the areas of bid packaging and equipment specification.

Because of this, the Board requested the Proponent to consider this principle, as it relates to design criteria, bid packaging and the timely dissemination of project information.

In response, the Proponent committed to:

> "ensure where possible Canadian and Newfoundland business capability is considered at the design and bid packaging stages and disseminate in a timely fashion the necessary project information to enable Canadian suppliers to prepare for participation in the project."
>
> (HBP, Supplementary Correspondence)

This commitment adequately responds to the Board's concerns on this matter.

2.3
Project Execution

The Board's review of the Hibernia Benefits Plan identified two major issues related to how the Proponent intends to execute the project. In the matters of the assembly of the Main Support Frame (MSF) and of project management and engineering, concerns have been raised by the Province. This section reviews the scope of these matters, summarizes the views of both the Proponent and the Province, and states the findings of the Board.

2.3.1
Project Management and Engineering

Project management and engineering services associated with the Hibernia project represent in excess of 4,000 person-years of employment. The Proponent estimates that at least 60 percent of these project requirements will be Canada-based and approximately 30 percent Newfoundland-based. The project management and engineering services employment demands, in person-years, are shown below:

Total Employment	4,150
Canada-Based	2,530
Newfoundland-Based	1,170

(Source: EIS Update August, 1985)

Newfoundland-based management and engineering activities include:

- overall project management, i.e. the Proponent's project management group supported by the project services contractor (PSC);
- GBS construction management; and,
- construction management associated with final topsides assembly.

Other Canada-based management and engineering activities include:

- topsides design engineering;
- GBS detailed design engineering;
- construction management associated with fabrication of preassemblies, deck sections and topside modules; and,
- construction management associated with the assembly and outfitting of the MSF.

Non-Canada-based management and engineering activities include:

- GBS preliminary engineering;
- ALP and subsea design engineering; and
- construction management associated with foreign-fabricated deck sections and topsides modules.

Topsides design engineering, the largest single engineering package associated with this project, will provide approximately 1,000 person-years of employment. The Proponent proposed executing the entire topsides design engineering at a single location, stating that this would ensure the most effective engineering management, control and scheduling.

The Province considers engineering to be a strategic benefits issue, and wants the project to provide for significant participation by locally based engineering firms and individuals in order to encourage the development of local skills. The Province's position is that a portion of the topsides design effort could be based in Newfoundland and has suggested that certain discrete components, for example, the living quarters, helideck and flare boom, representing approximately 10 percent of the total topsides design requirements, could be designed in the province without jeopardizing the project schedule. It points out that similar projects, in other areas, have been successfully managed in this manner.

The Proponent, in addition to the overall benefits commitment discussed earlier in this report, responded to this specific concern by committing to:

> "When cost effective, provide for maximum participation by Canadian and provincial firms in design engineering activities associated with all major components of the project, including topsides, GBS, ALP and drilling facilities, and where economically feasible, to execute discrete elements of the topsides design in Newfoundland."
>
> (HBP, Supplementary Correspondence)

The Board believes that it should not direct the Proponent to execute any portions of the project in a specific location, particularly if through that direction additional costs might be incurred. It is satisfied that the Proponent's commitment demonstrates a concern for the importance of this matter and for the need to examine carefully the feasibility of designing discrete project components in the province. It is the Board's intention to pay particular attention to this matter as the Proponent proceeds with contracting decisions.

2.3.2
Main Support Frame (MSF) Assembly

The Proponent's intention is to assemble the MSF and install cellar deck preassemblies at an unspecified eastern Canadian location outside the province. To conduct this work in Newfoundland, the Proponent estimated a substantial cost premium caused by, among other factors, additional site development and camp costs as well as lower labour productivity.

The Province considers MSF assembly and outfitting another strategic issue as it would provide a unique opportunity to develop greenfield assembly facilities in the province and would also provide an opportunity to train a diversified offshore-related labour force which would place the Province in an advantageous position for future offshore developments in Canada or elsewhere.

After reviewing the Proponent's cost estimates for assembling and outfitting the MSF at a Newfoundland location versus another eastern Canadian location, the Province concluded that the incremental cost associated with executing the work in the province was over-estimated by the Proponent.

As with the issue of project management and engineering, it is not the Board's intention to direct the Proponent to execute any portions of the project at a specific location. The Board is satisfied that the Proponent's commitments would result in the MSF assembly and cellar deck preassemblies installation at a Newfoundland location if there were no cost or schedule penalties involved. It is however, concerned about the variances between the incremental cost estimates of the Province and those of the Proponent.

CONDITION 3

It is a condition of the approval of the Hibernia Benefits Plan that the Proponent re-examine the feasibility of assembling and outfitting the main support frame in Newfoundland and provide further documentation to enable the Board to evaluate the matter.

2.4
Socio-Economic Issues

A number of socio-economic issues have been highlighted throughout the EIS review process. These issues range from housing and public infrastructure to employment equity and labour force displacement. This section describes the Proponent's position, reviews the findings of the Panel, and highlights the Board's conclusions. A complete listing of the Panel's recommendations can be found in Appendix A to this report.

2.4.1
The 'Boom Bust' Cycle

The Proponent has maintained that the project would not have a significant effect on national inflation and furthermore, that it is possible to accommodate a major project in a small local economy without triggering local inflationary effects.

The Panel noted that good planning can mitigate the 'boom bust' cycle. Planning should take into account potential shortages of supply which could cause inflation during the build-up phase and the opportunities for diversification of the economy during the phase-down of the construction activity.

The Board concurs with the findings of the Panel. It is also the Board's view that the impact of the 'boom bust' cycle will depend, to a large degree, on subsequent offshore development decisions and timing.

2.4.2
Population

The Proponent estimated that project impacts on population will be minimal in the affected communities of St. John's, Argentia and Come-By-Chance. However, the Proponent maintained that the impact of speculative job seekers on the population is not possible to estimate reliably.

The Panel concluded that the consequences of population increases can be managed, and recommended that timely information on expected population influxes be provided continuously by the Proponent and its contractors. (Panel recommendation #11). The Panel also suggested that the authorities further research the issue of speculative migration.

The Board recognizes the importance of providing timely information on labour demands, and agrees that the issue of speculative migration should be further researched by appropriate government authorities.

2.4.3
Housing

The Proponent stated that employment impacts on the communities affected should not lead to an unmanageable housing situation. In the case of St.John's, worker influx should not cause undue price escalation. In the Come-by-Chance area, the Proponent proposed establishing work camps to accommodate a large percentage of the construction workforce.

The Panel presented a number of housing related recommendations relative to St. John's, including increasing the supply of rental housing, providing additional facilities for transients and monitoring the demand for owner-occupied housing. The Panel also recommended discussions between the Proponent and affected communities relative to temporary family housing requirements. (Panel recommendations #12, 13, 14, 15).

These recommendations are outside the Board's regulatory mandate; however the Board supports the Panel's recommendation that the Proponent should engage in discussions with the affected communities relative to its temporary family housing requirements.

2.4.4
Public Infrastructure

The Proponent projected minimal impacts on schools, hospitals, municipal, commercial and industrial services and facilities in St. John's, Come-by-Chance and Argentia.

The Panel recommended full consultation among the Proponent, governments and communities to identify the necessary improvements in infrastructure. (Panel recommendation #16).

The Board agrees with the Panel that the Proponent should engage in discussions related to its infrastructure needs with the appropriate government agencies and affected communities on an ongoing basis during project planning and execution.

2.4.5
Social Services

The Proponent indicated that the province's social services system is presently over-extended but that the project should place minimal increases on demand.

The Panel concluded that the project could exacerbate social problems unless the social services system, now severely stressed, is adequately funded.

The Board acknowledges the findings of the Panel, however, implementation of its recommendation to provide additional funding is beyond the Board's mandate. The Board understands that other provincial agencies are considering this recommendation.

2.4.6
Work Camps

The Proponent proposed the utilization of work camps at Come-by-Chance and possibly, Argentia.

The Panel concluded that work camps could have a significant impact on the community but that if these camps are well designed and well run, potential problems could be minimized. In this regard the Panel recommended that the Proponent discuss the issue of camp location and access with the communites involved, and further recommended the provision of recreation facilities, medical services and counselling services in the work camps. (Panel recommendations #20, 21).

The Board agrees with the thrust of the Panel's recommendations; however the regulation of work camps is beyond the Board's mandate.

2.4.7
Labour Force Displacement

The Proponent's stated position on labour force displacement is that new employment opportunities may attract a limited number of workers from the fishery to the oil industry.

The Panel concluded that it is unlikely that the project will cause undue competition for workers. However, the Panel has recommended that this issue be considered in government's overall training strategy. (Panel recommendation #6).

The Board's view is that labour force displacement is not a critical, project-specific issue. Most provincial-based labour demands will be for the construction-related trades and will be of short-term duration. The demand for marine-related skills during the production phase could cause a limited but manageable level of labour force displacement. The Board agrees with the Panel that the issue should be considered in government's overall training strategy and recommends that this strategy should take into account long-term resource development projections.

2.4.8
Employment Equity

The Proponent, in its Benefits Plan, stated that it is an equal opportunity employer and committed to:

> "Provide disadvantaged groups with full and fair consideration for job opportunities in construction, development and operating phases of the project."

The Panel recommended that opportunities for increased employment of women offshore should be addressed through overall government policy and project-specific employment requirements. (Panel recommendation #7).

The Board agrees with the Panel's recommendations on this issue, and will be reviewing the Proponent's practices in the area of employment equity on a regular basis.

2.4.9
Management of Social Impacts

The Proponent indicated support for the concept of a 'single window' monitoring body and has committed to providing regular information related to its industrial and labour requirements, and other relevant project information, to this agency.

The Panel concluded that there is a need for a social management system involving senior levels of various government departments and recommended that community impact agreements be established. These agreements should address issues such as housing, infrastructure and social services. (Panel recommendation #19).

The Board agrees with the thrust of the Panel's recommendations and, as the single window agency, will provide the necessary project-specific information filed by the Proponent to various government agencies to aid in the management of social impacts.

2.5
Monitoring and Reporting

The Board believes that effective monitoring and reporting will be necessary to ensure that the Benefits Plan objectives are accomplished during the execution of the project. The Proponent supported the concept that a single window agency be responsible for direct liaison on the project.

The Panel recommended that the Board establish suitable mechanisms to ensure a continuing exchange of views among itself, government, the Proponent and the public during the life of the project. (Panel recommendation #48). The Board, through its legislative mandate, is required to be the single window regulatory and monitoring agency and will promote the exchange of information between the Proponent and governments.

The Board believes that it is neither necessary, nor productive, to monitor and approve all the Proponent's procurement decisions. An effective monitoring and reporting system, in the Board's view, should concentrate on key procurement decisions and provide for early disclosure of the Proponent's plans so that potential problems can be detected at an early date and corrective measures taken.

The Proponent, in its initial Benefits Plan, has committed to providing information related to its procurement and employment to this agency.

The Board, in seeking a more specific commitment, requested the Proponent to address this matter with a view to providing for the timely provision to the Board of information on project requirements, job descriptions and trades qualifications, procurement decisions and expenditure and employment matters.

The Proponent responded with a commitment to:

> "Carry out a program of timely reporting to the Canada/Newfoundland Board to enable the Board to monitor the level of efforts and benefits achieved and to assist in promoting maximum benefits, including:
>
> a) reporting to the Canada-Newfoundland Board on expenditures and employment on a basis to be determined by the Hibernia participants and the Board;
> b) providing the Board and the public with timely information on project requirements;
> c) providing the Board and such other authorities as the Board may direct, with specific information related to job descriptions and trades qualifications;
> d) advising the Board respecting any required foreign sourcing of major bulk materials and major equipment, and the rationale supporting the requirement to foreign source;
> e) advising the Board in a timely fashion of major contractor and procurement decisions at the pre-qualification, bid list and award stages, as follows:
>
> i) for the planned contracts and purchase orders listed in Attachment I, the scope of work and a list of proposed bid candidates for pre-qualification will be discussed with the Board. The Board will be expected to provide any comments on the list of proposed bid candidates within two days;
> ii) the final bidders' list selected (determined by a pre-qualification process including evaluation of questionnaires and interviews with bid candidates), supported by a review of the basis for selection, will be presented to the Board, prior to issuing enquiries to bidders to submit proposals;
> iii) proposals ultimately received from bidders will be assessed to determine the evaluated best bid. The results of the evaluation will be presented to the Board on a strictly confidential basis, one day prior to notification to the successful bidder."
>
> (HBP, Supplementary Correspondence)

The Board is generally satisfied with the Proponent's stated commitment to a monitoring and reporting process; however, there are two areas of concern to the Board: contracts subject to Board review prior to bid, and time allowed for the Board's review.

The Board is satisfied with the Proponent's proposal to submit certain major contracts and procurement decisions for the Board's review at the pre-qualification, bid list, and pre-award stages of the tendering process. However, the Board does not accept the list of major contracts provided by the Proponent as being definitive or all-inclusive.

CONDITION 4

It is a condition of approval of the Hibernia Benefits Plan, that as the project evolves, the Proponent provide to the Board comprehensive listings of all anticipated major contracts and purchase orders. The Board, in consultation with the Proponent, will determine which of these major contracts and purchase orders will be subject to Board review.

The second area of concern to the Board is the Proponent's imposition of time frames within which the Board has to conduct its review. It is the Board's intention to conduct its review of contracts and purchase orders in as expedient a manner as possible. In some cases the time allotments proposed by the Proponent may not be necessary and the Board response could be transmitted to the Proponent more quickly; however, there may be other contracts which would require a longer response time.

The Board views the imposition of response time limits by the Proponent as inappropriate. The Board must satisfy itself that the principles discussed previously are, in fact, being adhered to in these instances. The Board recognizes the importance of the Proponent's schedule in these matters and is confident that direct, open dialogue will avoid any undue delays.

CONDITION 5

It is a condition of the approval of the Hibernia Benefits Plan, that the Proponent provide advance notice of and information on major contracts and purchase orders to enable the Board to conduct its review. The review time required will be determined by the Board, in full consultation with the Proponent.

2.6
The Proponent's Benefits Strategy

This section quotes the Proponent's overall strategy to achieve benefits to Newfoundland and the rest of Canada throughout the Hibernia Project. The Proponent's contracting strategy is presented as well as its overall project management policies.

The Board feels that the Proponent's strategy represents an excellent plan for significant participation by Canadian industry and labour in the Project. The Board is particularly encouraged by the Proponent's commitment to consult with the Board on its contracting decisions. The Board also considers the Proponent's commitment to provide timely information to the Canadian market place to be critical to the achievement of benefits generally.

The Proponent's stated strategy is as follows:

"Strategy to Achieve Canada/Newfoundland Benefits

The strategy to achieve Canada/Newfoundland Benefits is summarized as follows:

- Establish a management organization to ensure direct control is maintained over all aspects of project execution, including design, construction and operation of facilities.
- Ensure the management organization becomes well informed of national and local supply capabilities.
- At appropriate stages during the project, identify national and local supply capabilities through methods such as vendor surveys, and as soon as feasible after project approval, begin communicating project requirements to the Canada-Newfoundland Board, local and national business associations, businesses, industry and governments.
- Develop detailed equipment lists as part of information packages at the earliest appropriate times during the project schedule for distribution as widely as practical to the Canada-Newfoundland Board, business associations, businesses and industry in general. Information will include details on equipment and materials required to be purchased:
  - directly by Mobil
  - by main contractors
  - by subcontractors

- Continue to support local research institutions and promote further research and development in Canada to solve problems unique to the Canadian offshore environment.
- As soon as personnel and skill needs requirements are identified, communicate these requirements to the Canada-Newfoundland Board, educational institautions and the public, and continue to update on a regular basis.
- Promote a clear understanding of the scale and timing of the project through direct communication and consultation with Newfoundland communities, institutions and residents. Develop specific project information programs for communities affected by project-related activities. Such programs will be communicated to interested groups such as community advisory committees, town councils and appropriate government agencies.
- Participate in community advisory committees to discuss solutions to problems related to site-specific industry-community impacts."

Source: HBP, Supplementary Correspondence

"Outline of Project Management and Contracting Strategy

The Hibernia Development Project will be managed out of St. John's, Newfoundland, by Mobil, whose staff will be assisted and augmented by suitably qualified personnel from a Project Services Contractor (PSC).

Engineering and procurement for the Topsides will be managed by Mobil, directing the services of the Engineering Procurement Contractor (EPC). This will include design and procurement of major equipment items for the Main Support Frame, the Modules and Preassemblies, and all other Topsides facilities, except for the Drilling facilities. The EPC, acting as agent for Mobil, will develop and award numerous contracts and purchase orders for equipment and services.

Fabrication of the Main Support Frame and Modules and Preassemblies, assembly of the Main Support Frame, and Module and Preassembly hookups will be carried out by other contractors. Mobil and/or PSC representatives will be present at all the sites to direct the work.

Design, procurement and fabrication of the Drilling facilities will be managed by Mobil through contractors other than the EPC. These contractors will also be awarding contracts and purchase orders for equipment and services.

Major contracts will be awarded by Mobil for engineering, procurement, construction and installation of the Gravity Base Structure and the Articulated Loading Platforms. These contractors will in turn award subcontracts and purchase orders for equipment and services. Mobil and/or PSC representatives will be present at all sites to direct the activities and participate in the review and approval process for award of major subcontracts and purchase orders.

Inshore and offshore hookup activities will be supervised by Mobil, either through a main contractor, or by Mobil's directly supervising the efforts of contractor-supplied personnel. Procurement and contracting for the equipment and services required during these periods will be handled directly by Mobil.

Other major project activities, including Marine Transportation and Lifting for Construction and Installations, building of Shuttle Tankers and Support Vessels, and Subsea Pipeline Installation, will be carried out by contractors directly engaged by Mobil, who will coordinate and review all of the activities.

Equipment and Materials
As the design phase proceeds, more definitive and specific lists of equipment and materials will become available. Equipment packages will be sized, wherever practical and cost effective, to encourage bidding by Newfoundland and Canadian suppliers. Information will be given on prequalification and bidding requirments and procedures to encourage the suppliers to participate in the bidding.

Topsides Contract: A large portion of the equipment and material will be purchased by the Topsides EPC as agent for Mobil. Mobil will ensure that the Topsides EPC becomes familiar with the resources of Newfoundland and Canadian suppliers.

These equipment and material lists will be disseminated in the Canadian and Newfoundland market place, e.g., through regional supplier organizations or their mailing lists, well ahead of bidders' lists being prepared and purchase enquiries being issued to enable interested equipment and material supply companies to qualify themselves for the bidders' lists.

Once bidders' lists are determined for specific equipment or materials, enquiries will be issued. After bids are received and evaluated, a recommendation will be made by the Topsides EPC for a purchase order to be placed with the evaluated best bidder. All steps throughout this process will be monitored by Mobil to ensure the specifications are met, that commercial and delivery terms are satisfactory and that qualified Canadian and Newfoundland bidders are evaluated fairly, on a competitive basis.

It will be a requirement that the Topsides EPC demonstrate and document to Mobil the efforts they have made to obtain bids from Canadian and Newfoundland suppliers who can meet project requirements.

Other Contracts: In the cases where fabrication/construction contractors will be required to purchase equipment (generally minor) and bulk materials (cement, reinforcing bar, outfitting steel, etc.), Mobil will require these contractors to seek bids from Canadian and Newfoundland companies qualified to bid. Also, to enable potential bidders in Canada to be aware of the requirement and timing of enquiries, the bidders for the fabrication contracts will be required to disseminate lists of equipment and material requirments in the Canadian market place, similar to the approach to be taken by the Topsides EPC. This will provide a basis for all other potential suppliers to provide equipment and material required to complete the fabrication.

Fabrication/Construction Contracts
With regard to the actual Fabrication Construction contracts, Mobil will prepare "packages", if practical and cost effective, in such a way that maximum opportunity will be available to Newfoundland and Canadian fabrication yards to utilize their capacity. Before developing bidders' lists for this work, Mobil will disseminate the scope specification and schedule requirements included in these packages to the market place in Canada and Newfoundland.

This will be done through the Canada-Newfoundland Board, trade organizations and their mailing lists, or other appropriate bodies or means.

Order of magnitude manhour requirements will also be disseminated to the market place and will generally cover various labour disciplines as follows:

- concrete workers;
- riggers;
- welders;
- pipefitters;
- electricians;
- instrument mechanics;
- millwrights; and
- sheet metal workers.

All this information will be out in the Canadian market place in time for potential fabrication/construction contractors to react and be considered for the bid lists. It will remain the responsibility of the contractors to develop their own manhour and manpower assessments.

Based on the work scope, a preliminary list of bid candidates will be developed. Prequalification questionnaires will be sent to each potential bidder. A reasonable amount of time will be allowed for all parties wishing to prequalify, to do so.

Evaluation of the prequalification questionnaires and bid candidate interviews will determine the bid candidates to be included on the final bidders' list. Enquiries will be sent to each bidder on the final bidders' list.

Bid submission and evaluation will follow strict procedures implemented by a designated bid evaluation team. The evaluated best bid will be selected.

Attachment 1
Hibernia Development Project Contracts
Canada-Newfoundland Offshore Petroleum Board Monitoring

- PSC/Topsides Engineering/Procurement
- GBS Engineering/Procurement/Construction/Mating/Installation
- GBS Mechanical Outfitting
- Main Support Frame Fabrication (possibly four contracts, for support rings, trusses and truss in-fills)
- Main Support Frame Assembly and Cellar Deck Outfitting
- Topsides Assembly/Outfitting
- Drilling Facilities Procurement/Construction
- Gas Compression Equipment Procurement
- Power Generation Equipment Procurement
- Topsides Module Fabrication
  - (a) Wellhead
  - (b) Living Quarters
  - (c) Gas Compression
  - (d) Power Generation
  - (e) Water Injection
  - (f) Utilities
- Marine Transportation and Lifting for Construction and Installation*
- Inshore/Offshore Hook-up
- ALP's Engineering/Procurement/Construction/Installation
- Subsea Pipeline Engineering/Procurement
- Subsea Pipeline Installation
- Shuttle Tankers
- Ice Clearing and Support Vessel

* Includes vessels, barges, tugs, etc., for transportation of modules from fabrication sites, lifting onto the deck, etc."

Source: HBD, Supplementary Correspondence

3.0
The Hibernia Development Plan

3.1
Introduction

The Hibernia Development Plan is approved by the Board subject to the conditions noted in this report.

The Plan set out the Proponent's interpretation of the geology and reservoir characteristics of the Hibernia oilfield, its estimates of the hydrocarbon reserves and its description of the approach it proposes to take and the facilities it proposes to install to recover those reserves. It also included a description of the parameters upon which the designs of facilities are to be based.

The Proponent stated that, in formulating the Development Plan, it relied upon studies by its own staff and contracted consultants and upon experience available to the participants.

The Board has reviewed the Development Plan to ensure that it conforms to the requirements established by law. The Board's duties in this regard are to ensure, insofar as is reasonably possible, that:

- the resource is produced in accordance with good oilfield practice having proper regard for the efficient recovery of the resource and the prevention of waste;
- the facilities which are installed are designed taking properly into account the environmental conditions to which they may be exposed, so as to maintain their integrity throughout the possible life of the field;
- a responsible approach is taken to environmental protection in the design of facilities and in the planning for contingencies; and,
- the safety of personnel is a primary consideration in the design of facilities, the choice of equipment, the development of operating procedures and contingency planning.

The Board notes that the Hibernia Development Plan is based upon preliminary design studies. Detailed engineering design has not begun and no equipment has yet been ordered. Consequently, the Board's review and approvals at this time are, of necessity, related to the concepts, approaches and undertakings described in the Plan.

As the detailed design proceeds, it will be necessary for the Proponent to obtain the additional approvals set out in regulations.

The examination of the detailed designs for a project as complex as Hibernia involves such a broad spectrum of expertise that no regulatory authority could expect to maintain the requisite staff. In recognition of this fact, the Production Installations Regulations, currently in draft format, provide for the licensing of Certifying Authorities to conduct detailed examinations of the designs on behalf of the regulator and, ultimately, to issue a Certificate of Fitness attesting to the suitability of the installation for its intended purpose.

Before being licensed as a Certifying Authority, a candidate must satisfy the Board that it has available sufficient expertise and experience to make the requisite judgements. The Board may license different Certifying Authorities for different purposes.

It is desirable, in the interest of reducing cost and duplication of effort, for a single Certifying Authority to have responsibility for a defined section of the project. For that part, it could act for the regulator, the insurer and the owner for their several purposes.

The Board has held preliminary discussions with the Proponent concerning its certification requirements. The Board intends, at an early date, to license Certifying Authorities to act on its behalf in reviewing the detailed designs for the major components of the project and for related purposes.

The Board is determined that the Hibernia project will be executed in an environmentally responsible manner and with special regard for the safety of the workers involved. These issues have been dealt with in a number of sections throughout the report.

The Development Plan itself has been carefully examined, bearing in mind the point in the evolution of detailed plans at which the project stands. Each topic will be introduced with a brief background section, the main areas of concern will be stated, and each of these areas will be discussed in detail ending with a statement of the Board's conclusion or decision regarding that particular issue.

THE HIBERNIA DEVELOPMENT PLAN DECISION

It is the decision of the Board that the Hibernia Development Plan is approved, subject to the conditions noted in this Development Plan Decision Report.

3.2 Geology

3.2.1 Introduction

In Chapter 2 of the Development Plan, the Proponent described the general geological setting, stratigraphy and structure of the Hibernia Field in some detail. This description is comprehensive and presents a good overview of the field and its main reservoirs, highlighting those factors such as lithology and diagenesis which play important roles in reservoir performance.

In this chapter, the Proponent also described the petrophysical processes and corrections to core and log data needed to prepare net hydrocarbon pay maps. A set of log correlations and net pay maps used for reserve estimates was included.

One important matter identified in this chapter relates to interpretation of the Avalon Reservoir. The Proponent's interpretation of net oil pay distribution for some areas of the reservoir differed from the interpretations of COGLA and NLPD. As a result of these differences, the joint COGLA/NLPD Review Committee (the Committee) disagreed with the proposed development plan for the Avalon Reservoir. The Board concurred with some of the Committee's views on this subject.

Because of the importance of the geological setting as a background to the Board's analysis of the Hibernia Development Project, the first seven sections of this part are included to provide a description of the geology of the field. The remaining sections deal with areas of particular concern to the Board.

3.2.2 Field Location

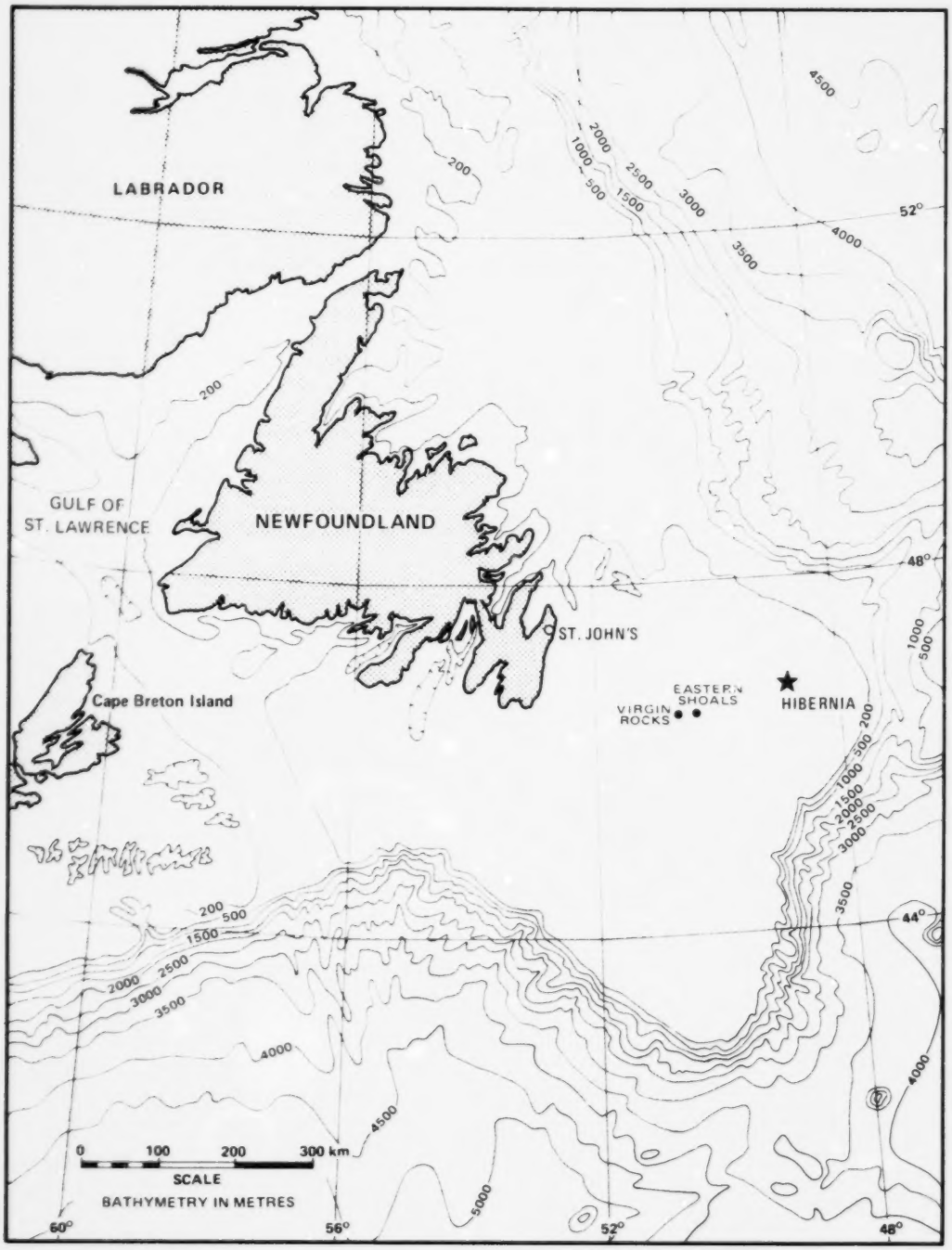
The Hibernia Field is located on the northwestern side of a sedimentary province known as the Avalon Basin by the Proponent and others, and as the Jeanne d'Arc Basin, by the Geological Survey of Canada and COGLA (Figure 3-1). The latter nomenclature has been adopted by the Board and is used in this report. It is noted that the term Jeanne d'Arc is applied by the Proponent to the sedimentary region south of the Hibernia Field.

3.2.3 The Jeanne d'Arc Basin

The Jeanne d'Arc Basin is at the southern end of a larger sedimentary province known as the East Newfoundland Basin. Both areas are bounded on the west by the Bonavista Platform, from which they are separated by a large fault system, referred to as the Murre Fault. The eastern boundary of the Jeanne d'Arc Basin is marked by the subcropping edge of pre-Cretaceous strata under the basal Tertiary uncomformity. The basin was formed during a rifting episode that preceded separation of the Grand Banks from the Iberia Peninsula. Rifting appears to have started in Middle to Late Triassic time and continued until Middle Cretaceous time when drifting of Iberia—Grand Banks may have been initiated.

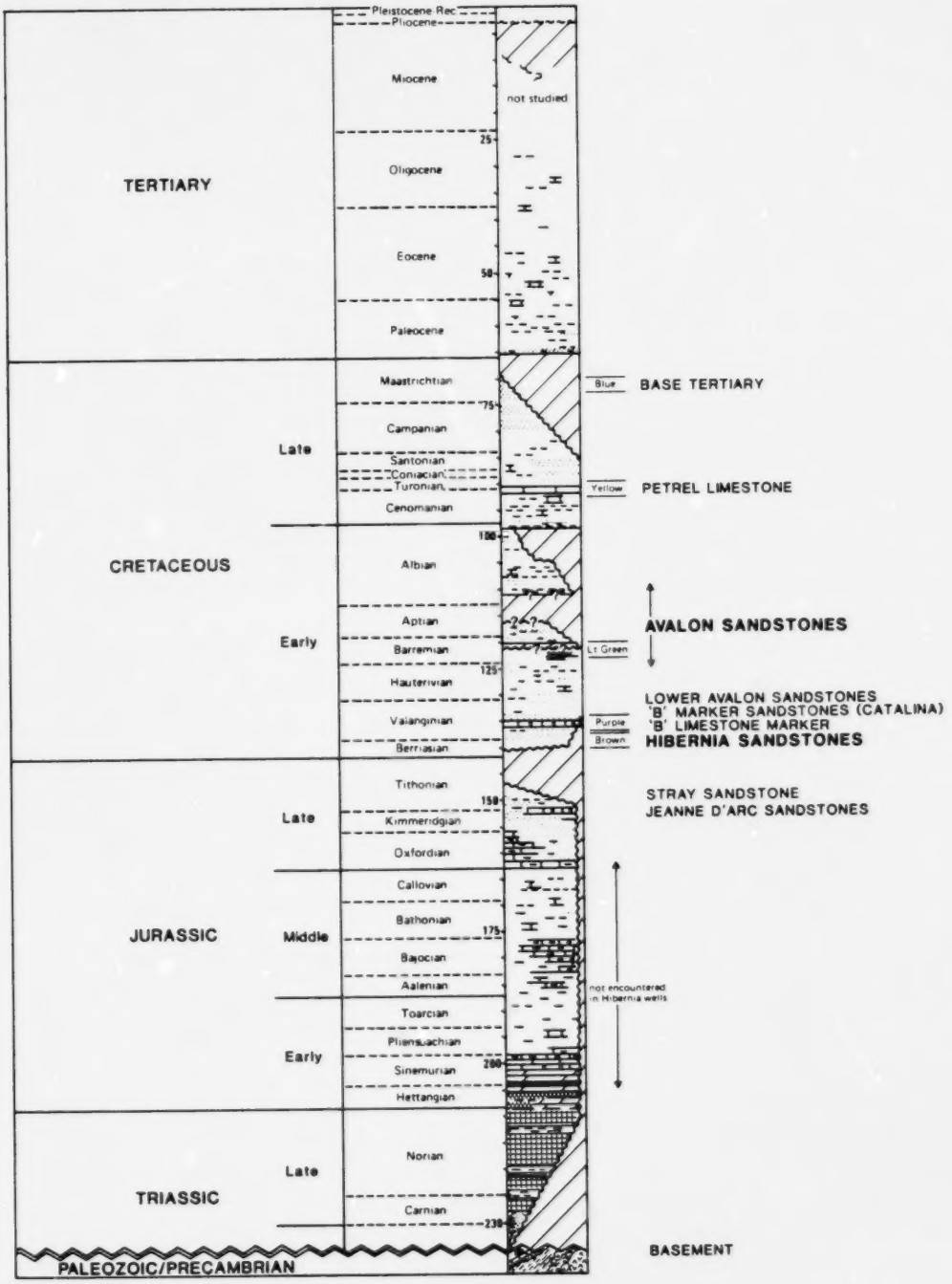
Within the Jeanne d'Arc Basin, a thick sedimentary sequence of Cenozoic and Mesozoic ages is present. The upper 5,000 metres of this sequence have been penetrated by the drill, and the presence of several thousand metres of additional sedimentary section can be inferred from seismic data and geological considerations. Clastic units predominate in the Tertiary and Cretaceous sediments, while the Jurassic and older Mesozoic strata are characterized by the abundance of carbonates and evaporites. Red bed sediments are present towards the base of the section.

Figure 3-1
Location of the Hibernia Field



Source: HDP, Figure 1.1-1

Figure 3-2
Generalized Stratigraphic Column
for the Hibernia Field



Source: Figure 2.2-2

3.2.4
Hibernia Field Stratigraphy

The stratigraphic sequence in the Hibernia Field is well established through drilling results. The sequence presented by the Proponent is shown in schematic manner in Figure 3-2.

The Tertiary section consists mainly of claystones and siltstones of marine origin with some interbedded sands. This section has a thickness varying from 1,200 metres on the west side of the field to 1,700 metres on the northeastern side. It rests unconformably on underlying Cretaceous sediments.

Cretaceous sediments consist of shales, siltstones and sandstones with some discrete calcareous units. Five of the six different hydrocarbon bearing zones in the field, including the two main reservoirs—Hibernia and Avalon—are in sands of Lower Cretaceous age. The lowermost sands are of fluvio-deltaic origin, with the remainder of the section becoming gradually more marine towards the upper part. Maximum drilled thickness of the Cretaceous section in the field is 2,900 metres. Seismic data indicate the presence of thicker sections towards the flanks of the field.

Upper Jurassic sediments, consisting of marine shales with intercalated sandstones named Jeanne d'Arc sands, have been drilled in the Hibernia Field. These constitute the deepest hydrocarbon bearing reservoir found in the field. Although only 1,000 metres have been penetrated by the drill, seismic data indicate the presence of a thicker Jurassic sequence below drilled depths.

Sedimentation of the Hibernia stratigraphic sequence was not continuous; several important uncomformities have been recognized, three of which are of regional nature while two seem to be of local importance.

Regional uncomformities mapped in the Hibernia Field and recognized also throughout large areas of the basin occur near the boundary Late Jurassic—Early Cretaceous, at Middle Albian time and between the Late Cretaceous—Early Tertiary times. Significant erosional events are associated with these uncomformities. Two other uncomformities present in the field have also been identified locally in some areas of the basin. According to the Proponent these are the "mid Barremian" and "mid Aptian" uncomformities which together with the "mid Albian" uncomformity, are sometimes called "break up uncomformity", apparently marking the initial drifting of the Grand Banks and Iberia Peninsula.

3.2.5
Reservoir Descriptions

Six different reservoirs were described by the Proponent in the Hibernia Field. In ascending order these are:

- Jeanne d'Arc sands of Upper Jurassic age
- Stray sands of Upper Jurassic age (Tithonian?)
- Hibernia sands of Lower Cretaceous age (Berriasian—Valanginian)
- "B" Marker sands of Lower Cretaceous age (Valanginian)
- Lower Avalon sands of Lower Cretaceous age (Valanginian—Hauterivian)
- Avalon sands of Lower Cretaceous age (Barremian—Albian)

Jeanne d'Arc Sandstones

These conglomeratic sands are the oldest reservoirs found in the field, and occur at depths of 4,070 to 4,575 metres subsea in those Hibernia wells that reached the sands. Those wells indicate a gross sandy interval ranging in thickness from 70 to 410 metres with individual sand members attaining thickness of 8 to 20 metres. Available data suggest a fluvio-deltaic origin for the Jeanne d'Arc sands.

Stray Sandstones

These 10-metre thick sandstones, known also as the Hibernia Stray Sandstones, were found in well B-08, where a test of interval 3,705 - 3,715 metres yielded oil and gas at daily rates of 386 m^3 and 64.5 x $10^3 m^3$ respectively. No detailed description of the characteristics of this reservoir was presented by the Proponent because of the limited information available.

The Board expects that future development drilling will provide a better understanding of this reservoir, whose contribution to the Hibernia resource base at this time is negligible.

Hibernia Sandstones
Hibernia sands were described by the Proponent as sublithic arenites, with minor quartz arenites, subangular to subrounded and moderately sorted. Although fine grains predominate, medium to coarse grains are also present.

The Proponent interpreted the depositional environment of these sands as a fluvio-deltaic system of distibutary channels, trending predominantly in a northeast-southwest direction, and postulated that lateral continuity is achieved through lateral migration of the original depositional channels with their associated sand bodies. Vertical continuity was postulated through successive stacking of channels and their incision into pre-existing channel deposits.

COGLA's studies further indicated that the Hibernia sands were deposited by streams flowing from southwest to northeast into a wave-dominated "high destructive" delta system with the sands gradually intertonguing with more marine beds in a northward direction, thus implying their eventual disappearance in that direction.

Gross thicknesses of the Hibernia sands range from 150 to 290 metres with individual sand members ranging in thickness from 8 to 25 metres. The Hibernia sands occur at depths between 3,450 and 3,890 metres subsea in those wells that reached the sands in the Hibernia Field.

"B" Marker Sandstones
These sands are present over most of the field and range in gross thickness from 140 to 260 metres. These thinly bedded calcareous sands are interbedded with siltstones and shales, all indicating a shallow marine environment, with associated bars and possibly estuarine sands according to the Proponent. Their depth range in the field is 2,800 to 3,300 metres subsea. These sands are also known as Catalina sands, a term accepted in the Board's nomenclature.

Lower Avalon Sandstones
These sands, found thus far in the northern part of the field, (Well B-08) at a depth of 2,645 metres subsea, tested oil and gas at daily rates of 489 m^3 and 60 x 10^3m^3 respectively. They have a gross thickness of 16 metres. A coastal or distal plain environment of deposition was suggested by the Proponent for these sands. As in the case of the Stray sands, the Lower Avalon current contribution to the field reserves will likely be negligible, and only future drilling will determine its eventual potential.

The name "Lower Avalon" used for these sands by the Proponent, does not correspond to the Board's adopted nomenclature, which uses this name for the lower sand member of the Avalon group, stratigraphically higher than these sands.

Avalon Sandstones
These were described by the Proponent as

> "sublithic arenites, with secondary component of lithic arenites, subarkoses and quartz arenites. They are moderately to well sorted, subangular to subrounded and very fine to fine grained . . . Carbonate cementation is common . . . and can result in the complete destruction of porosity".
> (HDP, Section 2.2.4)

These sands contain the shallowest and second most important reservoir in the field occurring at depths of 2,100 to 2,400 metres subsea. They have gross thickness ranging from 16 to 370 metres, although net thickness of individual sand members is much lower, ranging from 4 to 50 metres. The sands exhibit rapid lateral changes, particularly in an east-west direction from the center of the field.

The Proponent interpreted the environment of deposition as offshore bars, storm deposits and sheet-type sands that were deposited in dominantly low-energy marine and marginal marine environments that were episodically subjected to increased energy levels attributable to storm activities.

3.2.6
Hibernia Field Structure

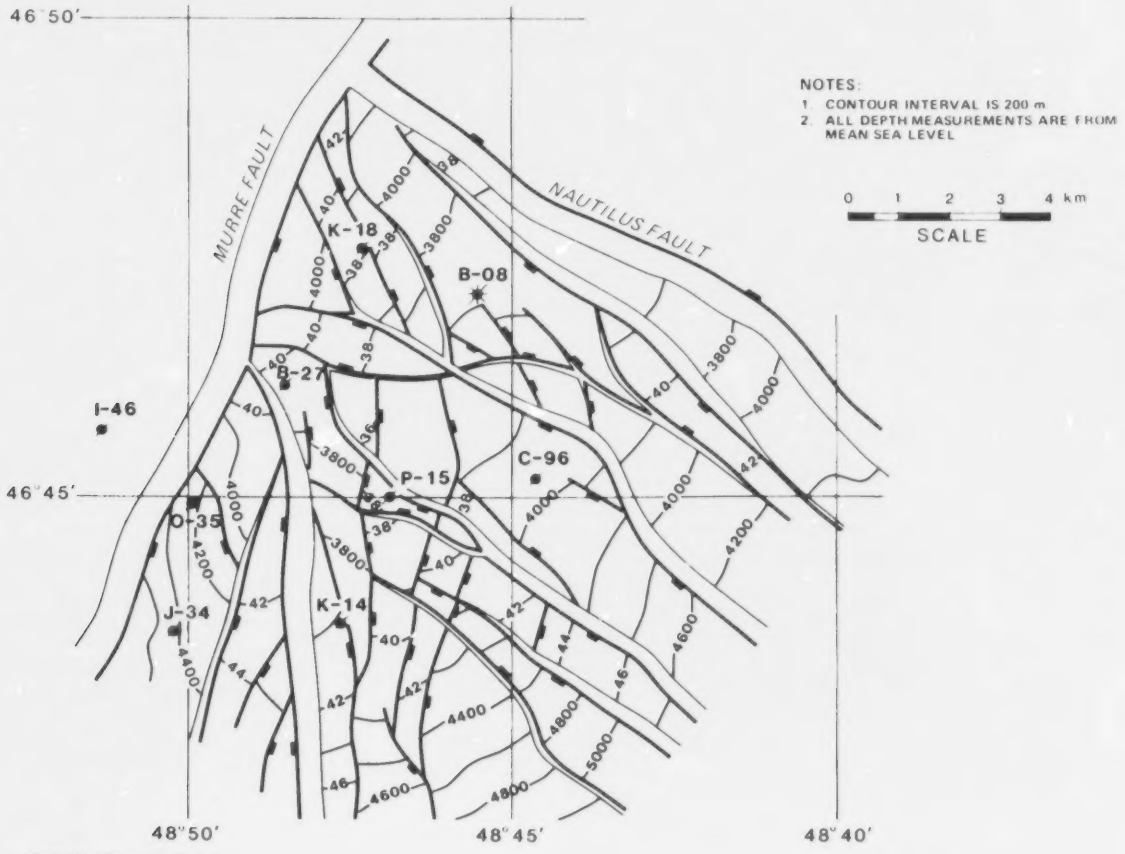
The Hibernia Field structural closure is formed by an anticline bound to the west and north by the large Murre and Nautilus Faults respectively. Figures 3-3 and 3-4 show the Proponent's structural interpretations for the Hibernia and Avalon Sands, and Figure 3-5 illustrates a diagrammatic cross section of the field.

The easterly dipping Murre Fault was mapped as a listric normal fault which flattens to an almost horizontal position at a depth of 15 to 20 kilometres according to the Proponent. The Nautilus Fault, with an offset of 1,500 metres or more, has a dip angle of 45 degrees to the northeast and was also interpreted as flattening with depth. Associated with these main faults is a system consisting of two groups of faults which cut the Hibernia anticline into a series of structural blocks. The Proponent referred to these faults as the "transverse set", striking in a northwest-southeast direction, and the "oblique set" trending roughly in a north-south direction. The oblique faults are less numerous and generally exhibit lesser displacements than the transverse faults.

Most faulting in the Hibernia Field occurred in late Lower Cretaceous time. Upper Cretaceous and Tertiary strata show only minor indications of tectonic disturbances.

The presence of the oblique and transverse faults is a critical element in the Hibernia Field development. If some are sealing faults, they may interrupt reservoir continuity by preventing the flow of fluids and pressure communication between different faulted blocks, possibly resulting in these blocks having their own pressure and fluid contact regimes.

Figure 3-3
Depth Map of the Base Hibernia Sandstones



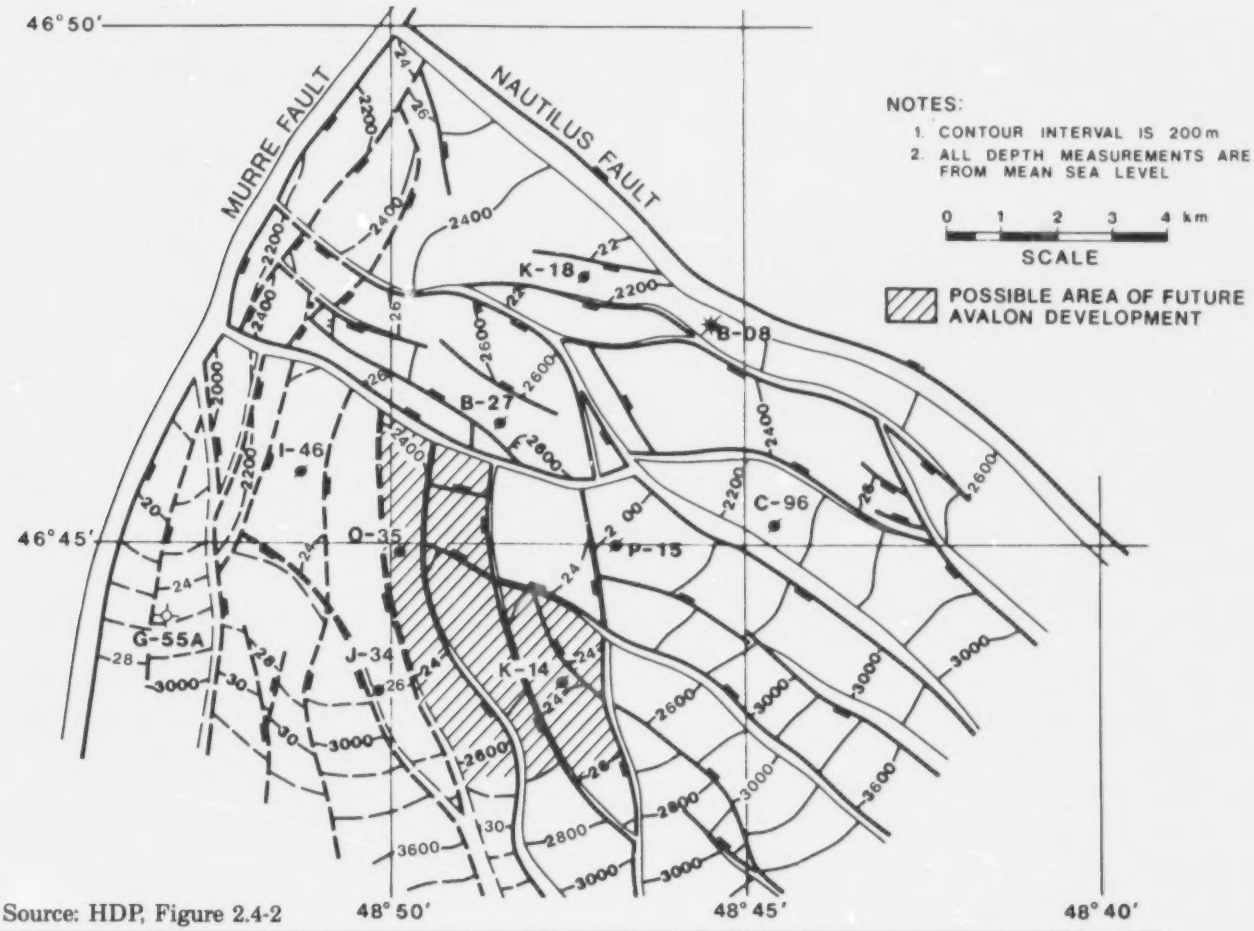
Source: HDP, Figure 2.4-1

COGLA and NLPD used, in their work, structural interpretations presented by Mobil prior to the submission of the Development Plan. These interpretations showed some of the fault positions at Avalon and Hibernia levels differing slightly from those submitted in the Development Plan, which are based on the most recent seismic work and interpretations. As the sealing nature of the faults cannot be ascertained from available data and must be determined through extended testing or production history, the small differences in mapping noted above lose some of their significance at this time and the Board accepts the Proponent's latest structural interpretation.

3.2.7
Generation and Migration of Hydrocarbons

The Proponent concluded that the oil found in the Hibernia Field was generated by shales and argillaceous limestones of the Jurassic period, which exhibit organic carbon contents in the range of one to three percent and higher. By comparison, the early Cretaceous section generally shows contents of less than one percent. The character of the kerogen found in those Jurassic sediments indicates an oil-prone source. These sediments have also been identified in other parts of the basin. The Proponent concluded that because the maturation level

Figure 3-4
Depth Map of the Avalon Sandstones
Base of Shale Marker No.2



Source: HDP, Figure 2.4-2

of those Jurassic sediments is not high enough under the Hibernia Field, generation took place in deeper parts of the basin, with hydrocarbons migrating to the structure from the deeper, more mature sediments. According to the Proponent's interpretation, generation and migration probably began in Early Tertiary time (60 million years ago).

Geochemical studies carried out by the Geological Survey of Canada agree with the Proponent's concept on the Jurassic source of the hydrocarbons. These studies further indicate that a mature source is found in the Hibernia Field below 4,200 metres, in sediments of Upper Jurassic age, within a rich zone with a thickness in the order of 300 metres, whose organic carbon content reaches levels of nine percent in wells Hibernia P-15 and K-18. Those studies also suggested that the oils in the field were generated over a wide range of maturation levels and emplaced in the reservoir at different times.

The differences noted above are of a scientific nature and have no bearing on the Development Plan.

3.2.8
Petrophysics

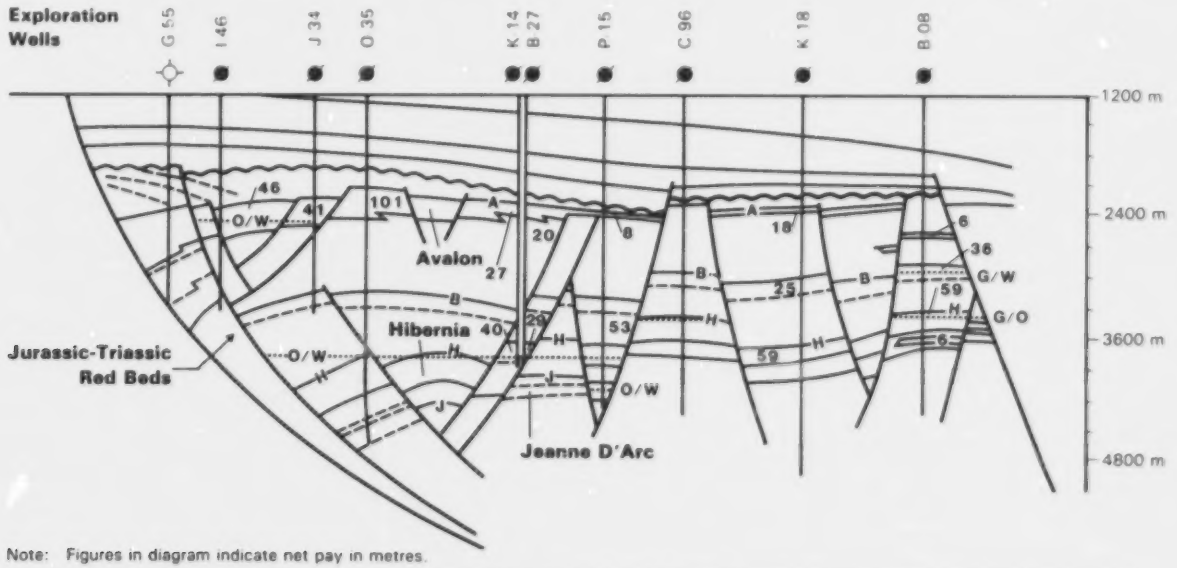
Logging and Coring Programs

Wireline logs run in the Hibernia Field were:

- Combination Dual Induction—Spherically Focused Log and Long Spaced Sonic—Gamma Ray—Caliper.
- Combination Dual Laterolog—Microspherically Focused Log and Synthetic Microlog—Gamma Ray.
- Compensated Neutron—Formation Density—Gamma Ray—Caliper.
- Four Arm Dipmeter and Directional Survey.
- Further, Repeat Formation Tester (RFT) and various engineering logs were run when required.

A total of 1,407.8 metres of section were cored with recovery of 386 metres in the Hibernia sands and 782.7 metres in the Avalon sands. These cores were analyzed for porosity, permeability, grain density and residual saturations.

Figure 3-5
Diagrammatic Cross Section of the Hibernia Field



Note: Figures in diagram indicate net pay in metres.

Legend

A	Avalon Sandstones	J	Jeanne D'Arc Sandstones
B	'B' Marker Sandstones	G/O	Gas-Oil Contact
H	Hibernia Sandstones	G/W	Gas-Water Contact
		O/W	Oil-Water Contact
		Scale	0 1 2 3km

Computation and Cut-off Parameters
Laboratory core analyses were used to calibrate log response and determine in situ porosity and horizontal permeability from corrected log values. These relationships provided cut-off limits and computational parameters to estimate hydrocarbons in place.

Table 3-1 indicates cut-off values used by the Proponent, COGLA and NLPD. The Board finds the procedures used in arriving at these values to be consistent with good engineering practices. It further observes that differences in cut-off values will affect estimates of original oil in place, discussed under section 3.3.

The Proponent included log correlations and net pay maps for the Hibernia and Avalon Reservoirs, and considered them to be the two principal reservoirs in the field, containing the bulk of the reserves.

A similar conclusion was reached by COGLA and NLPD and is adopted by the Board.

3.2.9
Reservoir Correlations

Hibernia Reservoir
Hibernia Sandstones were subdivided by the Proponent into three sand "layers" as shown by diagrammatic log in Figure 3-6.

The lowermost layer 3, varies in thickness from 75 to 121 metres; layer 2 has a thickness ranging from 17 to 28 metres, and the upper layer 1 has a thickness ranging from 46 to 117 metres. Each of these layers consists of individual sand members of variable thickness and areal extent, which are expected to be in communication with each other both vertically and laterally. Vertical communication occurs through the stacking of channel sands, each of which has incised into pre-existing channels, while lateral connections are created by lateral migration of channels and associated sand bodies.

Both COGLA and NLPD also subdivided the Hibernia Reservoir into three separate sand sequences. Although the tops and bottoms of these sequences did not coincide with the Proponent's, they closely agreed on the top and bottom of the entire sand section.

Avalon Reservoir
The Avalon Sandstones were subdivided by the Proponent into four "layers" (Figure 3-6). The lower of these, layer 4, varies in thickness from 40 to 206 metres. Thickness ranges for the other three layers are 6 to 157 metres for layer 3, zero to 116 metres for layer 2, and 20 to 136 metres for layer 1.

Rapid changes in reservoir characteristics are observed in these layers particularly in the east-west direction, the sands gradually shaling out from the center of the field towards the east and becoming tighter to the west.

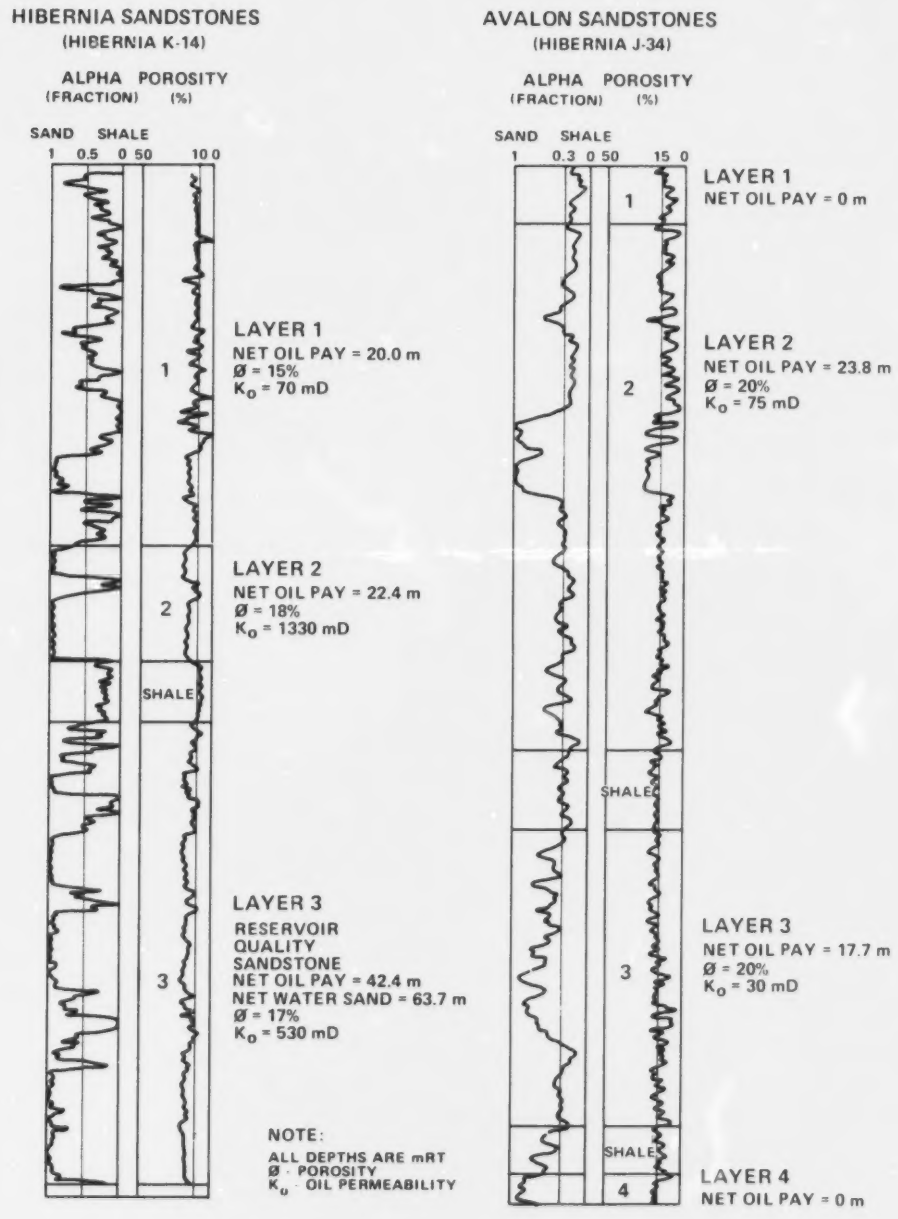
COGLA and NLPD subdivided the Avalon Reservoir into three layers separated by shale markers. The threefold subdivision corresponds to the Proponent's fourfold subdivision. The observed differences in correlations are not considered a major factor in hydrocarbon estimates for the Hibernia Field.

Table 3-1
Comparison of Cut-off Values
Hibernia and Avalon Reservoirs

Characteristic	Hibernia			Avalon		
	Proponent	COGLA	NLPD	Proponent	COGLA	NLPD
Porosity (%)	10	10	10	15	15	14.5
In situ permeability to oil (mD)	1	1	1	1	1	1
Water saturation (%)	70	50	50	70	50	50
GR Alpha	0.5	0.35	0.5	0.4	0.35	0.4-0.5
Minimum bed thickness (m)	NA	0.5	NA	NA	0.5	NA

NA: Not available

Figure 3-6
Diagrammatic Log Analyses
for the Avalon and Hibernia Sandstones



Source: HDP, Figure 3.2-1

3.2.10
Net Pay Maps

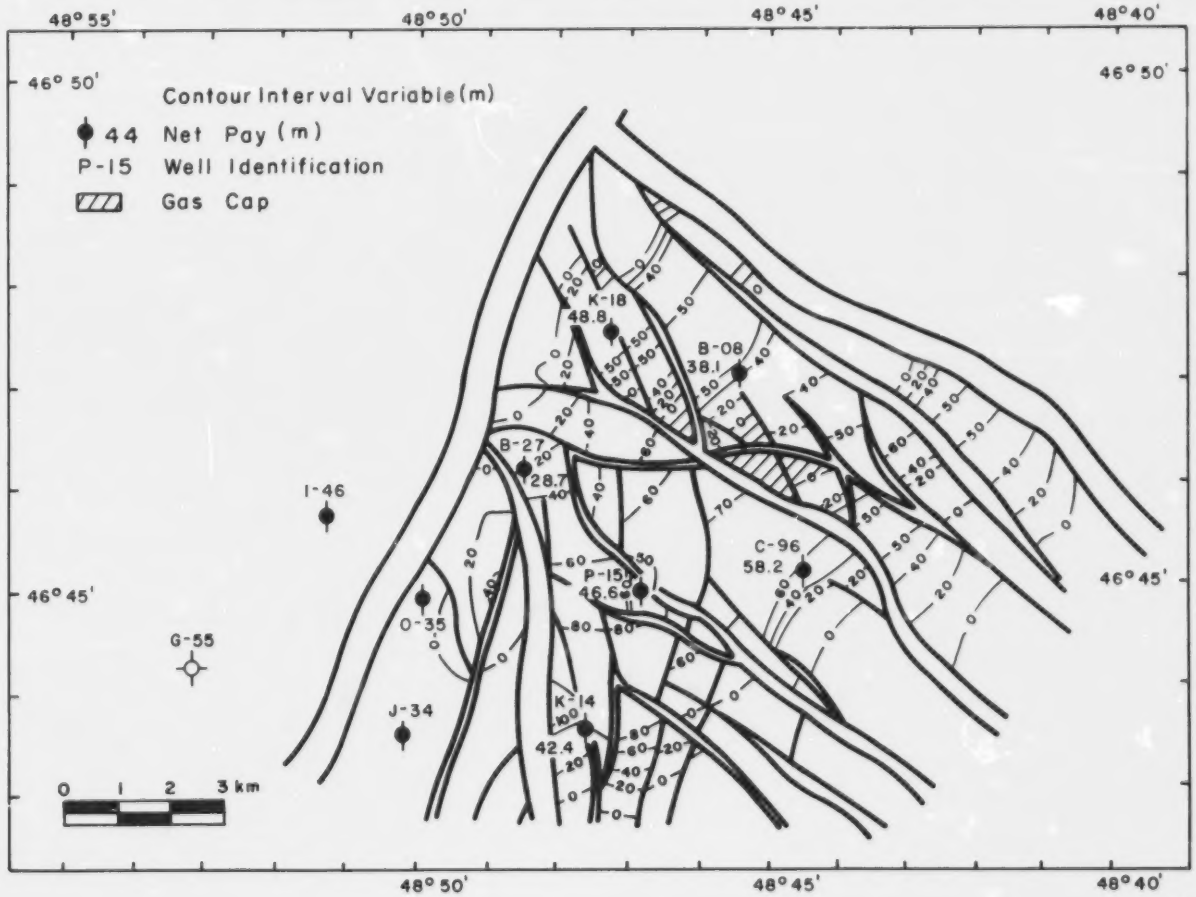
Hibernia Reservoir

Using log correlations, corrected reservoir parameters with established cut-off values were derived to construct net pay maps. The Proponent presented three isopach maps of net oil pays corresponding to the three layers into which it subdivided the Hibernia Reservoir. Using these data, the Board's staff made one composite map representing the total net oil pay for the three layers of the Hibernia Reservoir, (Figure 3-7).

According to the Proponent, two oil-water contacts were recognized in the Hibernia sands, one at 3,862 metres subsea in well P-15, and the second at 3,930 metres subsea identified by tests in well B-27. The former contact was said by the Proponent to be restricted to a small graben block where wells P-15 and O-35 are located. The latter contact was considered more representative of the field oil-water interface. These contacts in some cases were derived from log analyses. Both were identified within layer 3. One gas-oil contact was determined in B-08 well at 3,544 metres subsea.

COGLA's and NLPD's isopach maps of net pays for their respective threefold subdivisions of the Hibernia Reservoir were also compiled by the Board's staff into the single maps illustrated in Figures 3-8 and 3-9. COGLA assigned to each faulted block the net pay determined for the well in that block, under the assumption that such value was representative of the average net pays in individual fault blocks. Thus, no contours appear on the compilation of COGLA's Hibernia Reservoir maps.

Figure 3-7
Composite Net Oil Pay
Hibernia Reservoir (after Proponent)



It is the view of the Board that the oil-water contacts and gas-oil contacts used by the Proponent for the Hibernia Sandstones are acceptable for planning purposes. However, evaluation of the pressure/depth data carried out by the Board's staff indicates the presence of multiple hydrostatic pressure systems and the possibility of other oil-water contacts.

The location of fluid contacts affects estimates of oil in place and recoverable reserves. However, the Board feels the Proponent's development strategy will enable the fluid contacts to be established in key regions of the reservoir early in the development plan.

Table 3-2 shows a comparison of the total net oil pays for the Hibernia and Avalon Reservoirs, as determined by the Proponent, COGLA and NLPD in each well. Differences observed in this Table result in contour differences in the net oil pay maps.

The Board recognizes the interpretive nature of these results as well as the subjective character of the contour configurations in the net pay maps, and considers that the observed differences, while having no impact on the Development Plan, will affect volumetric estimates of recoverable hydrocarbons.

Avalon Reservoir

Four net oil pay isopach maps were presented by the Proponent, corresponding to the four "layers" into which it subdivided the Avalon Reservoir. These maps were compiled into a single net oil pay map by the Board's staff. (Figure 3-10).

A probable oil-water contact in the Avalon Reservoir was postulated at 2,602 metres subsea, based on log analysis, Drill Stem Test (DST) results and Repeat Formation Tester (RFT) data in well J-34, and supported by log analysis in well I-46. No evidence of gas cap was identified in this reservoir.

Table 3-2
Comparison of Net Oil Pays
Principal Reservoirs Hibernia Field
(metres)

	Avalon			Hibernia		
Well	Proponent	NLPD	COGLA	Proponent	NLPD	COGLA
I-46	46.3	28.9	24.0	ND	ND	ND
J-34	41.5	19.4	29.0	ND	ND	ND
O-35	100.6	78.2	67.0	0	0	0
K-14	26.8	23.2	20.0	42.4	35.6	37.0
B-27	22.2	18.7	9.0	28.7	21.2	12.0
P-15	8.2	7.0	10.0	46.6	44.0	25.0
C-96	3.0	0	0	58.2	57.6	63.0
K-18	18.6	13.1	12.8	48.8	46.2	54.0
B-08	1.8	0	0	38.1	36.8	43.0

ND: Not Drilled

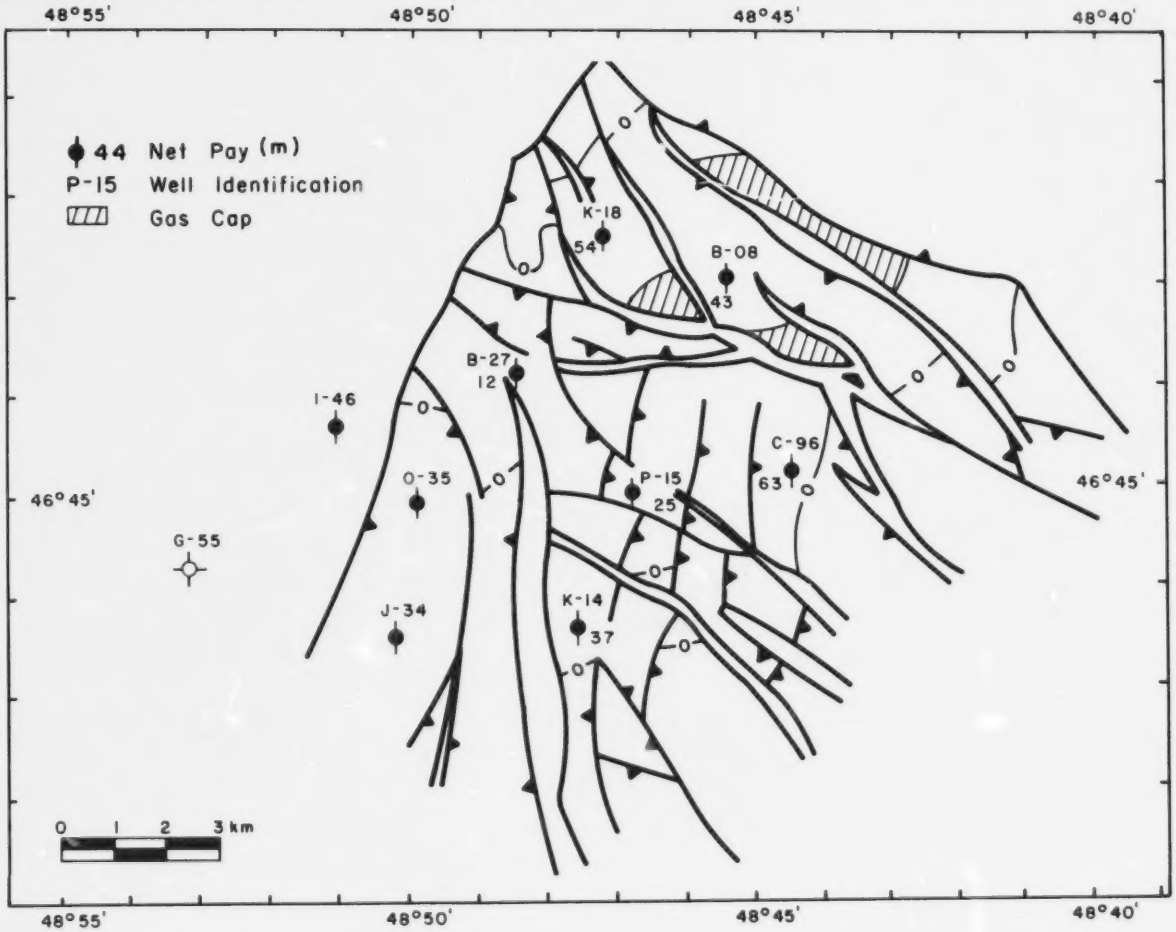
The Board's compilation into one map of COGLA's and NLPD's isopach maps of net pays for the Avalon Reservoir is presented in Figures 3-11 and 3-12. The Proponent's and COGLA's maps, considered to represent "likely pays" were used with their close equivalent, the "Proven plus Probable" maps of NLPD.

The Board believes that the oil-water contact used by the Proponent for the Avalon Sandstones is acceptable. As in the case of the Hibernia Sandstones, multiple hydrostatic pressure systems are indicated from the pressure/depth plots for the Avalon Sandstones. It is the Board's opinion that the Proponent's development strategy will enable the fluid contacts to be established in the area of possible development in the early stages of the project.

A significant difference was noted between the interpretation of the Proponent's layer 3 and its approximate equivalent in NLPD's layer 2 representing proven plus probable net pays. This difference exists in the northern part of the Avalon structure, where extrapolation of data by NLPD indicated the probable presence of significant pay thicknesses in an area left undrilled during the field's delineation process. The Proponent included this area among those having

> "insufficient oil pay, inadequate productivity and insufficient per well reserves to justify development".
>
> (HDP, Section 3.4.1).

Figure 3-8
Composite Net Oil Pay
Hibernia Reservoir (after COGLA)



Although the Board recognizes the subjective character of the interpretations presented by the different parties regarding the northwest area, and considers that these differences can be resolved through further drilling, in the absence of this further information the Board does not accept the Proponent's quoted views on this matter.

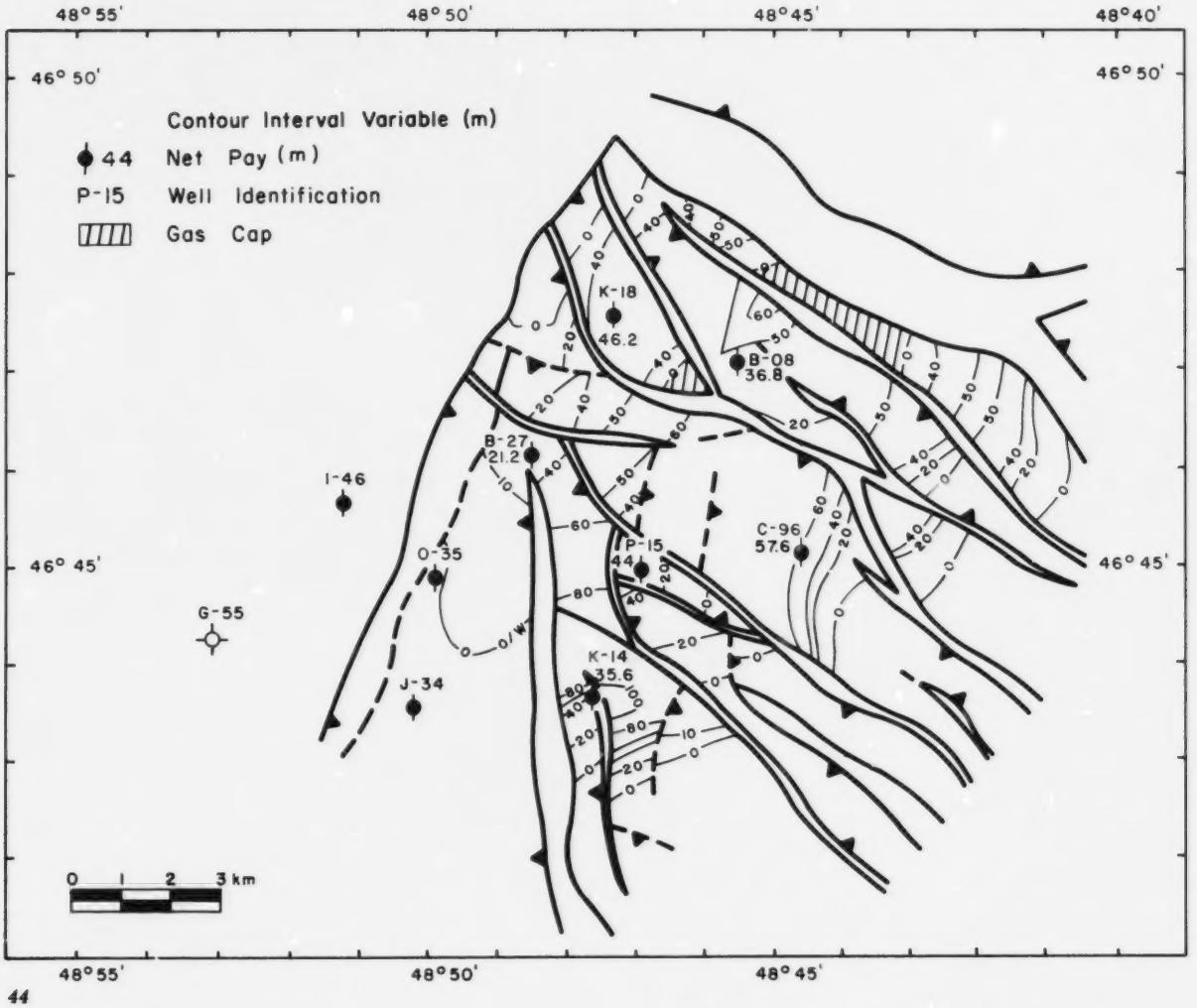
Subordinate Reservoirs

According to the Proponent,

> "hydrocarbons located in the Lower Avalon, Hibernia Stray and Jeanne d'Arc Sandstones are localized and believed to be beyond economic recovery . . . [based on] pressure depletion observed in all available drill stem tests"
>
> (HDP, Section 3.5.3).

Thus, no net pay maps for these subordinate reservoirs were presented by the Proponent. Studies by COGLA and NLPD arrived at similar conclusions on the limited nature of these three reservoirs.

Figure 3-9
Composite Net Oil Pay
Hibernia Reservoir (after NLPD)



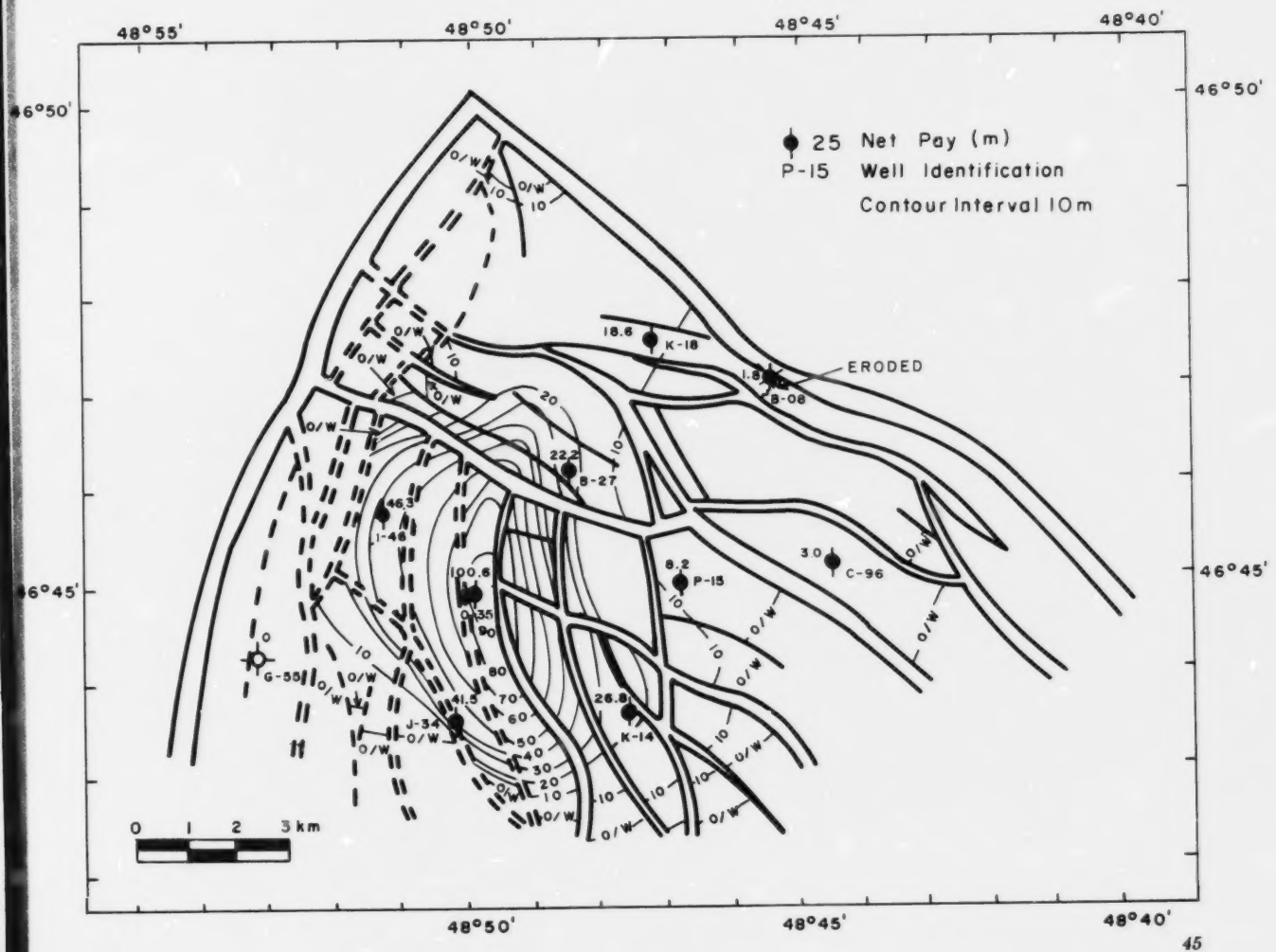
The Board agrees with these conclusions and further observes that the potential resource contribution from these subordinate reservoirs can be evaluated in a more definitive manner in later years, after additional drilling has taken place in the field.

The fourth subordinate reservoir, the "B" Marker, also known as the Catalina sands, is more widespread over the field than the other subordinate reservoirs, with hydrocarbon pay zones identified in four wells (B-27, K-18, C-96 and B-08).

The Proponent stated that

> "pressure depletion observed in drill stem tests and the unpredictable nature of the reservoir fluid contacts between wells, indicate hydrocarbon occurrence in the "B" Marker to be of limited areal extent . . . waterflood of this reservoir is not believed to be feasible and an estimated 5% recovery factor by primary depletion can be expected . . . [which is] insufficient to warrant development".
>
> (HDP, Section 3.5.3)

Figure 3-10
Composite Net Oil Pay
Avalon Reservoir (after Proponent)



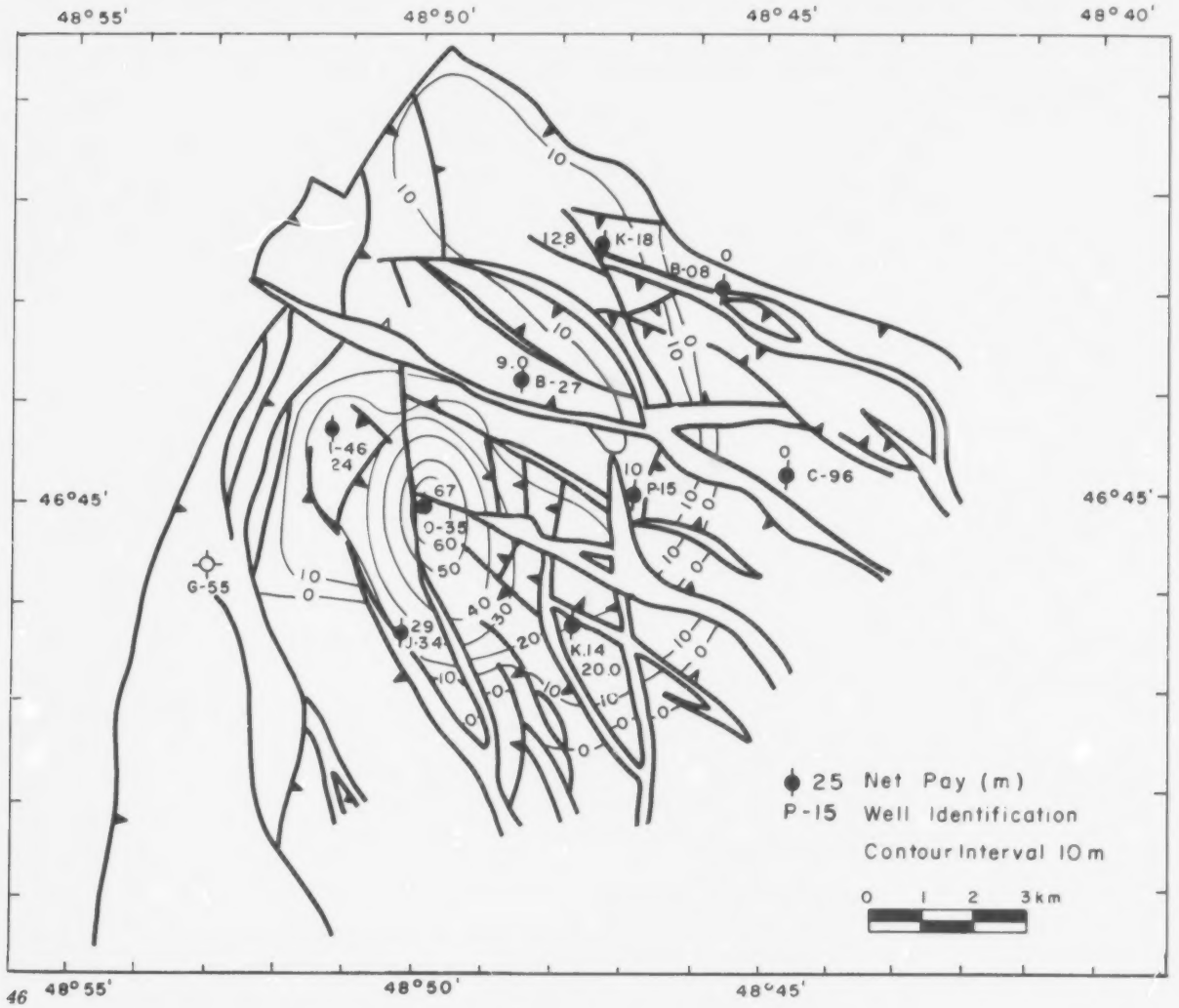
COGLA and NLPD agreed in general with the Proponent's views on the "B" Marker, and concurred with the Proponent on the subordinate nature of this reservoir which does not permit its early development.

The Board agrees with the Proponent's and the joint COGLA/NLPD's views on the nature of the "B" Marker, and further observes that during development drilling of the Hibernia sands, the "B" Marker should be evaluated and more conclusive information on its resource potential obtained.

3.2.11
Board's Conclusions

As a result of its analysis, the Board concludes that the Proponent's geological descriptions of the Hibernia Field and its reservoirs are consistent with those of COGLA, NLPD and the Board. The Board also concludes that the stratigraphy and reservoir correlations of the Hibernia Reservoir presented by the Proponent are generally consistent with the interpretations of COGLA, NLPD and the Board. The differences noted in net pay maps are not enough to affect the Development Plan for the Hibernia Reservoir.

Figure 3-11
Composite Net Oil Pay
Avalon Reservoir (after COGLA)



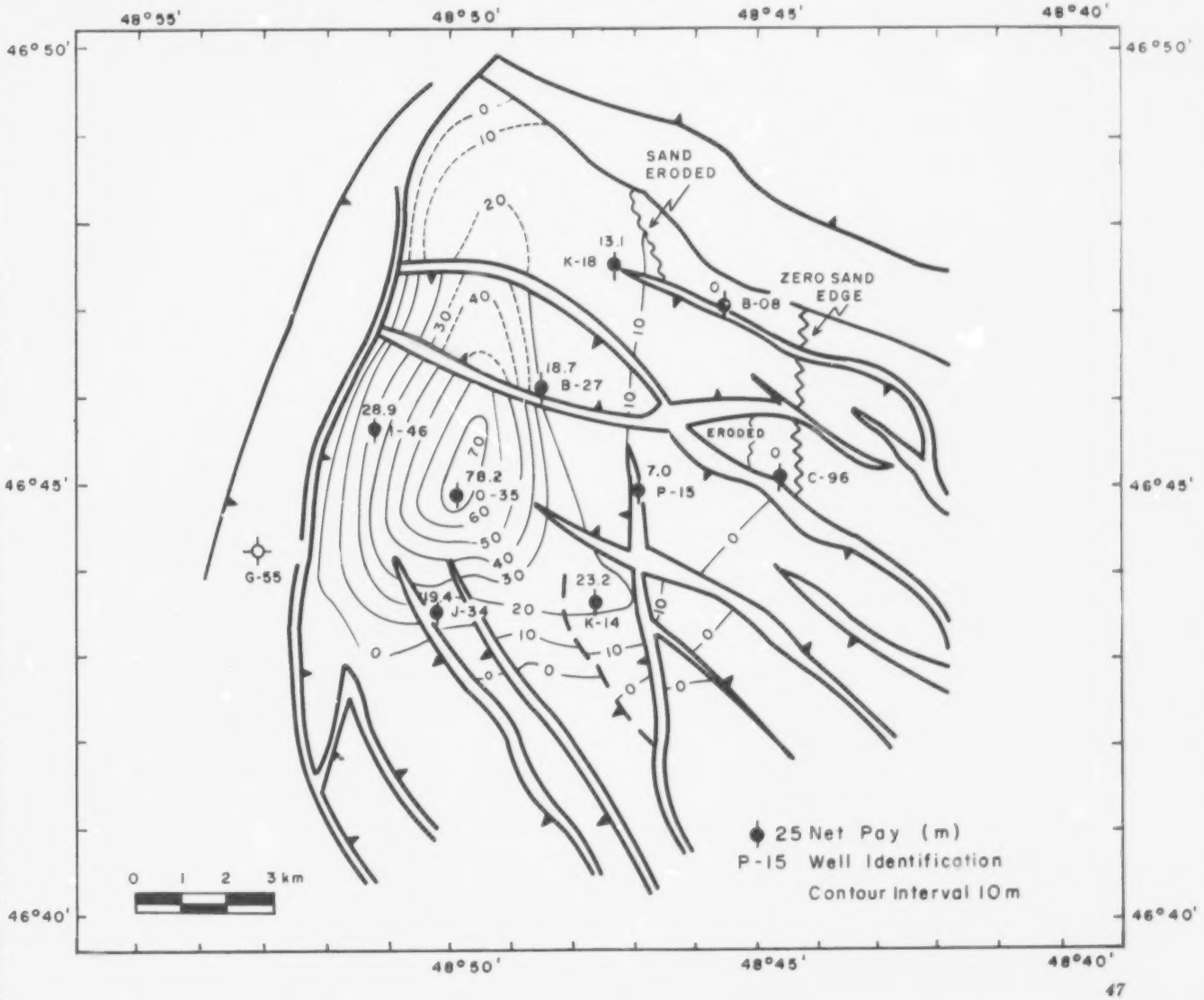
The Board accepts the Proponent's views on the limited extent of the contributions to reserves from the "B" Marker Sandstones, the Lower Avalon Sandstones and the Stray Sandstones. The Board does not, however, accept the Proponent's views on the extent and distribution of net oil pay of the Avalon Reservoir. Further discussion of this issue is presented in Section 3.3.4.

3.3
Reservoir Engineering

3.3.1
Introduction

In Chapter 3 of the Development Plan, the Proponent reviewed basic reservoir data and presented estimates of hydrocarbons in place and recoverable hydrocarbons in the two principal reservoirs. The

Figure 3-12
Composite Net Oil Pay
Avalon Reservoir (after NLPD)



Development Plan was presented in a conceptual manner for the Hibernia Reservoir, with production commencing in 1992 through a system capable of handling 24 x 10^3 m^3 of oil per day. A plan for possible production from a limited area of the Avalon Reservoir was also presented, with tentative production starting in the year 2000 when Hibernia Reservoir production was postulated to begin declining.

The presentation by the Proponent was thorough and, for the most part, well supported by technical data. In reviewing this area, the Board identified two aspects of the Development Plan which require more attention. These were the possibility of a miscible flood for the Hibernia Reservoir and the plan to flare gas.

In addition it became apparent that significant differences exist between the Proponent's views on the Avalon Reservoir and those of COGLA and NLPD. These differences led the Committee to disagree with the Proponent's plan to develop this reservoir. The Board also noted some differences in the reserve estimates prepared by the Proponent, COGLA and NLPD. These differences, however, do not affect the development plan for the Hibernia Reservoir.

3.3.2

Basic Reservoir Data

The Proponent presented a substantial body of information acquired during drilling in support of its estimates of original oil in place, recoverable reserves and development and production strategies. Some of the assumptions, analytical techniques and results of log and core data used for these purposes were reviewed in the previous section. Additional data required for reserve studies are reviewed in this section.

Residual Saturation End Points

Waterflood residual saturation end points were determined using relative permeability, flood test and capillary pressure data. Resulting residual oil saturations given by the Proponent ranged from 31.0 percent to 34.5 percent for various layers of the Hibernia
Reservoir, and from 27.2 percent to 29.3 percent for layers of the Avalon Reservoir.

It was noted by the Proponent that effective gas-oil relative permeability end points could not be established from gas flood tests conducted on Hibernia Sandstone cores, as these experiments were terminated at relatively high gas-oil mobility ratios.

The Board considers that end points for gas flooding in the Hibernia Sandstones are an important factor which requires further investigation, as the degree of residual oil saturation in gas flooding will have a direct impact on displacement efficiency and recoverable oil reserves.

The Board intends to ask the Proponent to conduct additional analytical studies to establish gas flood end points and to file those results with the Board before production begins.

Well Test Data

The Proponent conducted extensive testing programs to evaluate reservoir performance and establish parameters needed for reservoir studies. Fluid samples from the five most recent wells were used as the basis of pressure-volume-temperature data. Further, an injectivity test was conducted on the C-96 well, which indicated pressure maintenance of the Hibernia Sandstones by water injection would be feasible.

It is the Board's opinion that the testing program conducted by the Proponent was sufficient.

Fluid Properties

Table 3-3 from the Development Plan summarizes fluid properties for the Hibernia and Avalon Reservoirs. Oil properties are fairly uniform for the Avalon Sandstones, while for the Hibernia Sandstones the properties vary significantly with depth. Gas cap fluid properties of the Hibernia Sandstones were estimated using a gas specific gravity determined from repeat formation tester pressure gradients.

Table 3-3
Fluid Properties

Well	DST No.	DST Interval (m RT)	Sandstone	Layer	Reservoir Conditions					
					Pressure (MPa)	Temp. (°C)	Oil Density (kg/m^3)	Oil Viscosity (mPa.s)	Oil Gravity (°API)	Bubble Point (MPa)
P-15	6	3852-3858	Hibernia	3	40.886	98.9	685.7	0.72	34.5	31.854
	8	3805-3822	Hibernia	2	40.672	98.3	647.7	0.52	36.1	36.315
	10	3742-3746	Hibernia	1	40.313	97.8	655.1	0.44	35.0	36.039
O-35	4	2342-2349	Avalon	4	25.545	64	748.1	1.60	29.0	21.360
B-08	6	3604-3613	Hibernia	3	40.472	100	644.2	0.31	40.3	40.372
G-55A					— Not Tested —					
K-18	4	3804-3812	Hibernia	3	41.038	101.1	652.2	0.40	35.0	37.797
J-34	10	2481-2498	Avalon	2	26.000	73.3	757.7	1.29	32.6	19.540
I-46	10	2458-2465	Avalon	3	25.750	65.6	757.8	1.31	30.5	20.988
	12	2387-2405	Avalon	2	24.820	65.6	749.9	1.19	30.7	21.084
B-27	4	3904-3911	Hibernia	3	41.160	98.3	635.8	0.43	37.3	35.577
	6	3850-3860	Hibernia	2	40.800	96.7	612.9	0.29	37.9	37.590
	7	3782-3786	Hibernia	1	39.800	95.0	625.5	0.30	32.7	38.528
	11	2578-2583	Avalon	3	26.860	77.2	732.4	0.90	32.3	24.835
	12	2550-2561	Avalon	3	26.650	76.1	731.3	1.00	33.1	24.559
K-14	2	3933-3945	Hibernia	2	41.320	97.6	680.6	0.58	32.3	33.667
	3	3901-3909	Hibernia	1	41.050	97.2	686.6	0.56	33.9	30.840
	5	2419-2423	Avalon	4	25.780	70.0	767.9	1.68	32.0	17.651
	6	2395-2400	Avalon	3	25.600	69.4	762.6	1.36	32.0	18.788
	7	2375-2383	Avalon	3	25.450	67.8	763.8	1.45	32.7	19.057
	8	2344-2371	Avalon	3	25.250	66.7	752.7	1.28	32.7	19.036
C-96	1	3940-3945	Hibernia	3	41.465	104.4	679.7	0.58	30.2	32.130
	3	3869-3875	Hibernia	3	41.217	101.7	672.7	0.48	32.9	32.916
	4	3843-3854	Hibernia	2	41.031	101.1	663.6	0.44	33.1	34.101
	5	3784-3787 3796-3801	Hibernia	1	40.750	100.6	660.2	0.44	33.6	32.371
J-34	3	2595-2609	Avalon	3	26.840	77.8	747.8	1.21	32.9	20.284
	7	2570-2585	Avalon	3	26.640	76.7	744.2	1.07	30.3	21.643

DST: Drill Stem Test RT: Rotary Table

Source: HDP Table 3.2-5

Miscibility Experiments
Miscibility experiments were conducted on representative oil samples obtained from B-27 DST #4 and C-96 DST #1, using typical Hibernia process injection gas compositions from these wells and an enriched injection gas. The Proponent noted that miscibility was almost achieved at initial reservoir pressure and that similar experiments, using a composition theoretically estimated for gas cap gas, indicate that misciblity is achieved at current reservoir conditions. The Proponent commented that these results should be treated with caution because of uncertainty regarding the composition of the gas in the gas cap.

Both COGLA and the NLPD were of the opinion that conditions within the Hibernia Reservoir (especially in the regions overlain by the gas cap) appear favourable for a miscible flood by injection of gas into the gas cap.

The Board recognizes the technical difficulties associated with the feasibility study of a miscible flood at this time, and with the possible implementation of a miscible flood in a geologically complex reservoir such as the Hibernia Sandstones. The Board, however, concurs with the Committee's observations on possibly improving oil recoveries through a miscible process in parts of the Hibernia Reservoir.

The Board considers that a comprehensive approach is needed during initial development drilling to provide the field and laboratory data necessary to identify areas of the reservoir that may benefit from miscible flood. The Board believes that the fault block in which the B-08 was drilled is the most likely area to benefit from this process.

CONDITION 1

It is a condition of the approval of the Hibernia Development Plan that the Proponent:

(i) at a very early stage in the development program, drill a well in the area of the B-08 gas cap, to obtain gas cap samples for laboratory analyses and define a gas-condensate-oil regime; and

(ii) undertake studies, concurrent with initial development drilling, to establish the feasibility of a miscible flood for the Hibernia Reservoir.

3.3.3
Estimates of Hydrocarbons in Place

The ranges of original oil-in-place (OOIP) and original gas-in-place (OGIP) estimates for the Hibernia and Avalon Reservoirs given by the Proponent, COGLA and NLPD are shown in Tables 3-4 and 3-5, while estimates for subordinate reservoirs are given in Table 3-6.

Estimates of oil and gas in place have not been prepared by the Board. The Board considers that estimates presented in those tables conform to good engineering practices and that the differences observed are the result of the different parameters used by the three parties. In arriving at estimates of recoverable reserves, some compensating effects for part of these differences are provided by differences in recovery factors used by each party, a subject dealt with under Section 3.3.7.

3.3.4
Development Plan and Production Strategy

The Proponent plans a full development of the Hibernia Reservoir, and possible partial development of the Avalon Reservoir as Hibernia Reservoir production begins to decline around the year 2000. According to the Proponent,

> "Avalon reserves are confined within the area covered by the 25 development wells as illustrated by Fig. 3.4-2 [Figure 3-13]. West of this area, the reservoir is of poor quality as evidenced in the high degree of stratification and unfavourable well test results in wells I-46 and J-34".
>
> (HDP, Section 3.4.1)

The Proponent also stated that

> "after some production history has been obtained from the developed area, the Avalon Sandstones lying outside this area would be considered through a possible stepwise appraisal program".
>
> (HDP, Section 3.1.3)

Hibernia Reservoir
Except for the concern expressed in Section 3.3.5 about the need for drilling gas injection wells early in the schedule, the Board is satisfied with the Proponent's plan for developing the Hibernia Reservoir.

Table 3-4
Original Oil in Place
Avalon and Hibernia Sandstones
(10^6m^3)

Category	Source	Hibernia Full Field Development	Possible Area of Future Avalon Development	Avalon Full Field Development	Hibernia Full Field Plus Possible Area of Avalon Development	Hibernia Full Field Plus Avalon Full Field Development
Downside	Proponent	NA	NA	NA	NA	NA
	NLPD	225	79	177	304	402
	COGLA	215	NA	140	NA	355
Likely	Proponent	214	104	254	318	468
	NLPD	225	87	223	312	448
	COGLA	215	NA	140	NA	355
Upside	Proponent	NA	NA	NA	NA	NA
	NLPD	225	93	278	318	503
	COGLA	307	NA	179	NA	486

NA: Not available

Table 3-5
Original Gas in Place
Avalon and Hibernia Sandstones
(10^9m^3)

	Solution Gas			Gas Cap Gas			Total		
Sandstones	Proponent	NLPD	COGLA	Proponent	NLPD	COGLA	Proponent	NLPD	COGLA
Avalon Full Field Development	24.8	20.9	14.5	—	—	—	24.8	20.9	14.5
Possible Area of Future Avalon Development	9.1	8.3	NA	—	—	—	9.1	8.3	NA
Hibernia Full Field Development	46.5	51.9	48.0	18.8	14.5	12.6	65.3	66.4	60.6
Total Full Field	**71.3**	**72.8**	**62.5**	**18.8**	**14.5**	**12.6**	**90.1**	**87.3**	**75.1**
Total Possible Area of Future Development	55.6	60.2	NA	18.8	14.5	12.6	74.4	74.7	NA

NA: Not Available

Table 3-6
Original Oil and Gas in Place
Subordinate Sandstones
(10^6 m^3)

Category	Source	"B" Marker K-18	"B" Marker B-08	Lower Avalon	Hibernia Stray	Jeanne d'Arc
Original Oil in Place	Proponent	2.0	—	0.75	0.50	0.08
	NLDP	18.6	—	0.65	0.60	0.40
Original Gas in Place	Proponent	—	3800.0	—	—	—
	NLPD	—	4575.0	—	—	—

Avalon Reservoir

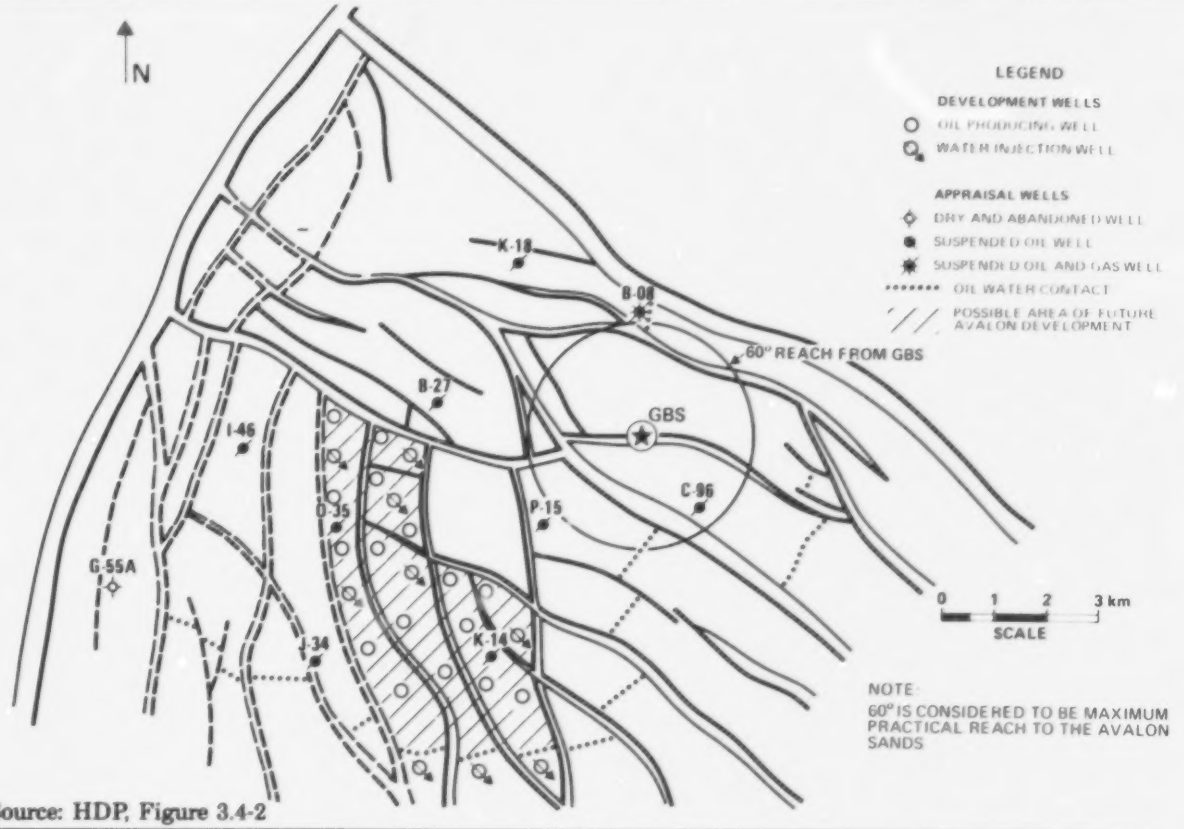
The Committee expressed its disagreement with the Proponent's development plan for the Avalon Reservoir, and stressed three principal concerns regarding this plan:

- exclusion of portions of the Avalon Reservoir from development drilling;
- timing and mode of Avalon development; and
- lack of delineation drilling on the northwest portion of the Avalon structure.

The Committee's concern was that the Proponent's Avalon development plan fails to allow for the possibility of the Avalon Reservoir having greater potential to add to economically recoverable reserves than the estimates considered by the Proponent. The Committee believed that significant recoverable reserves are likely to be found outside the possible area of future Avalon development shown by the Proponent (Figure 3-13), in particular in an area to the northwest part of the Avalon structure left untested during the delineation process.

Lack of information raises questions regarding the interpretation of the potential of this area, which is assumed to be non-commericial by the Proponent, viewed optimistically by NLPD, and considered to be in need of drilling by the Committee. These opinions, in turn, lead to different views regarding the timing of Avalon Reservoir drilling and development. If the Committee's projections were realized, there would be a significant increase in the recoverable reserves available to the project. It was, however, acknowledged by the Committee that although productivity and recovery factors from the Avalon Sandstones are still not well established, they are no doubt lower than those expected from the Hibernia Sandstones.

Figure 3-13
Proposed Development Well Layout
Avalon Sandstones



Source: HDP, Figure 3.4-2

As a result of the above, the Committee suggested that consideration be given to earlier development and delineation drilling and production testing of the Avalon Reservoir. This would allow concurrent production of the Avalon and the Hibernia Reservoirs, if this should prove to be an attractive alternative.

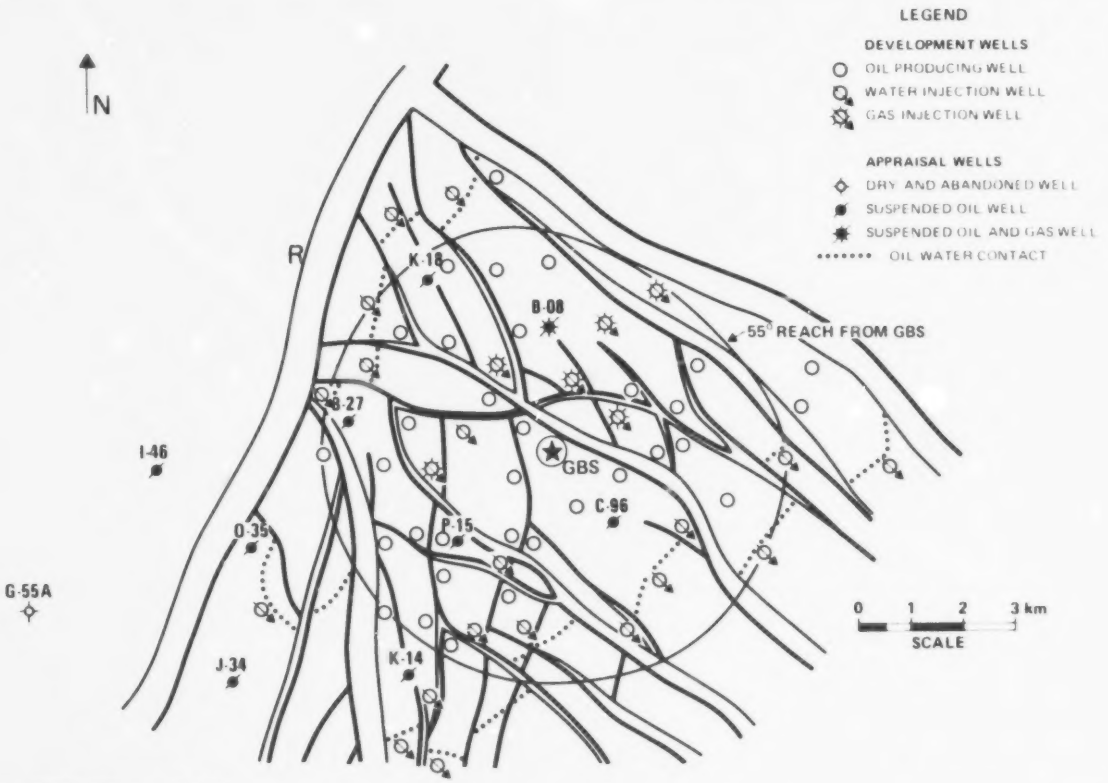
The problems related to the timing of Avalon Reservoir development involve not only its lower reservoir quality when compared with the Hibernia Reservoir, but also its relative position. Figures 3-13 and 3-14 highlight this problem. Wells drilled from the Gravity Base Structure (GBS) to develop the Hibernia Reservoir, will intersect the Avalon sands in a small area where the Avalon Reservoir is either absent or poorly developed. Areas of expected better Avalon development would have to be drilled from floating units, requiring expensive drilling operations and subsea completions.

The Board considers that these conflicting views, as well as the geological concerns expressed by the Committee, need to be weighed against the financial burdens that would be imposed on the overall project if the Avalon Reservoir were to be developed earlier than envisioned by the Proponent. This would require either:

- substantial additional investment in topside facilities to accommodate Avalon production in addition to the proposed Hibernia production, or
- displacement of production from Hibernia with production from Avalon.

While the Board has not done its own financial analyses of these matters, it is satisfied that the overall project economics would be impaired by displacing Hibernia production with Avalon production. It also believes that the evidence is not strong enough at this time to support installation of additional production capacity on the GBS structure to provide for Avalon production.

Figure 3-14
Proposed Development Well Layout
Hibernia Sandstones



Source: HDP, Figure 3.4-1

Notwithstanding these conclusions, the Board will expect the Proponent to continue to evaluate the potential of the Avalon Reservoir and to consider possible ways to exploit the reservoir earlier than that proposed in the Development Plan.

CONDITION 2

It is a condition of the approval of the Hibernia Development Plan that:

(i) prior to any development of the Avalon Reservoir, the Proponent submit a revised plan for the Board's approval;

(ii) during development of the Hibernia Reservoir, the Proponent evaluate the Avalon Reservoir by coring, logging and testing all prospective zones penetrated by wells drilled to the Hibernia Reservoir; and

(iii) during the design of topside facilities, the Proponent give due consideration to sizing equipment and allocating space for production facilities and utilities, sufficient to accommodate additional production from the Avalon Reservoir concurrently with Hibernia production, should there be a requirement to produce the Avalon Reservoir prior to the time contemplated in the Development Plan, and that the Proponent report to the Board on its actions in this regard before the topside facilities design is finalized.

3.3.5
Production Mechanisms

The Proponent plans to maintain the Hibernia Sandstones pressure by injecting gas into the gas cap and by water injection along the flanks into the aquifer. If the Avalon Sandstones were developed, the Proponent would maintain pressure by water injection into layers 2 and 3. Layer 4 would be produced by primary depletion. Layer 1 would not be exploited due to anticipated low oil recovery.

Initially the Proponent plans to complete in layer 3 in the Hibernia Sandstones, followed by the simultaneous completion in layers 1 and 2, as production declines. Simulation studies indicate that this completion practice as well as producing oil wells at rates of 2 380 m^3/d and 1 190 m^3/d in waterflood and gas flood situations, respectively, is appropriate.

The Proponent has stated:

> "Some gas flaring will be necessary prior to drilling of gas injection wells. Gas flaring may also be necessary if gas injection is not successful". (HDP, Section 3.4.2)

The Board concludes that the Proponent's pressure maintenance scheme for the Hibernia and Avalon Reservoirs and the planned completion practices are acceptable.

The Board does not approve the Proponent's gas flaring plans.

CONDITION 3

It is a condition of the approval of the Hibernia Development Plan that:

(i) the Proponent file for approval by the Board, prior to commencement of development drilling, a specific drilling schedule designed to reduce gas flaring to limits acceptable to the Board;

(ii) in the unlikely event that reservoir conditions prevent gas re-injection, the Proponent present to the Board for approval a plan for gas disposal;

(iii) the Proponent obtain the Board's approval to flare those small volumes of gas needed for normal operations.

3.3.6
Development Wells

The Proponent is planning to drill 58 and 25 development wells for the Hibernia and Avalon Sandstones, respectively. The exact locations and numbers of wells will be selected as development proceeds and reservoir characteristics are more clearly identified.

Drilling commences with the use of two platform rigs in the first quarter of 1992. Platform wells with least deviation to the Hibernia Sandstones are likely to be drilled first. Gas and water injection wells will be drilled in a timely manner to maintain pressure. More highly deviated platform wells and subsea wells will then be drilled to maintain a production capacity of 24 x 10^3 m^3/d.

The Board accepts the Proponent's approach and plan for development drilling of the Hibernia Reservoir provided that the Board's requirements on gas disposal are adhered to.

Table 3-7
Recoverable Reserves
Avalon and Hibernia Sandstones
(10^6m^3)

Category	Source	Hibernia Full Field Development	Possible Area of Future Avalon Development	Avalon Full Field Development	Hibernia Full Field Plus Possible Area of Avalon Development	Hibernia Full Field Plus Avalon Full Field
Downside	Proponent	NA	NA	NA	NA	NA
	NLPD	81	12	19	93	100
	COGLA	54	NA	12	NA	66
Likely	Proponent	71	12	23	83	94
	NLPD	94	19	43	113	137
	COGLA	75	NA	28	NA	103
Upside	Proponent	NA	NA	NA	NA	NA
	NLPD	108	29	73	137	181
	COGLA	107	NA	36	NA	143

NA: Not available

3.3.7
Recoverable Reserves

The Proponent noted that an areal reservoir simulation study, based on immiscible displacement, was performed on the Hibernia Sandstones. Recovery factors obtained from that study indicated an average likely factor of 33 percent.

The Proponent added that in areas of favourable geology and with communication across faults, or in areas with favourable fluid miscibility behaviour, recovery factors of 40 percent or more could result.

An areal reservoir simulation study was also performed on the Avalon Sandstones over the possible area of future development shown by Figure 3-13. Because of known problems with stratification and uncertainties over vertical and horizontal continuity of individual sands, the recovery factor used by the Proponent was 11 percent. This was based on engineering judgement as well as on simulation results.

Regarding the "B" Marker, the Proponent stated that, because of the nature of the reservoir, a successful waterflood is not believed feasible and a 5 percent primary recovery factor could be expected, which would not justify development.

The Proponent further stated that

> "no potential resources have been estimated for the remaining subordinate sandstones, primarily due to pressure depletion observed in all available drill stem tests. The hydrocarbons located in the Lower Avalon, Hibernia Stray, and Jeanne d'Arc Sandstones are localized and believed to be beyond economic recovery".
>
> (HDP, Section 3.5-3)

Both COGLA and NLPD conducted reserve appraisals for the Hibernia Field. COGLA conducted an areal simulation study and estimated recovery factors based on engineering judgement and analogy with other fields.

NLPD used the results of areal reservoir simulation studies and engineering judgement to estimate the recovery factors for the Hibernia Sandstones. Recovery factors obtained from the areal simulation studies ranged from 25 to 55 percent in waterflood fault blocks and from 28 to 39 percent in combination waterflood and gas flood fault blocks. The lower recovery factors in the combination flood blocks were largely attributable to the end points selected for gas flood. These were considered pessimistic by NLPD.

Table 3-8
Average Recovery Factors
Avalon and Hibernia Sandstones
Percentage

Category	Source	Hibernia Full Field Development	Possible Area of Future Avalon Development	Avalon Full Field Development
Downside	Proponent	NA	NA	NA
	NLPD	36	15	11
	COGLA	25	NA	9
Likely	Proponent	33	11	9
	NLPD	42	22	19
	COGLA	35	NA	20
Upside	Proponent	NA	NA	NA
	NLPD	48	31	26
	COGLA	35	NA	20

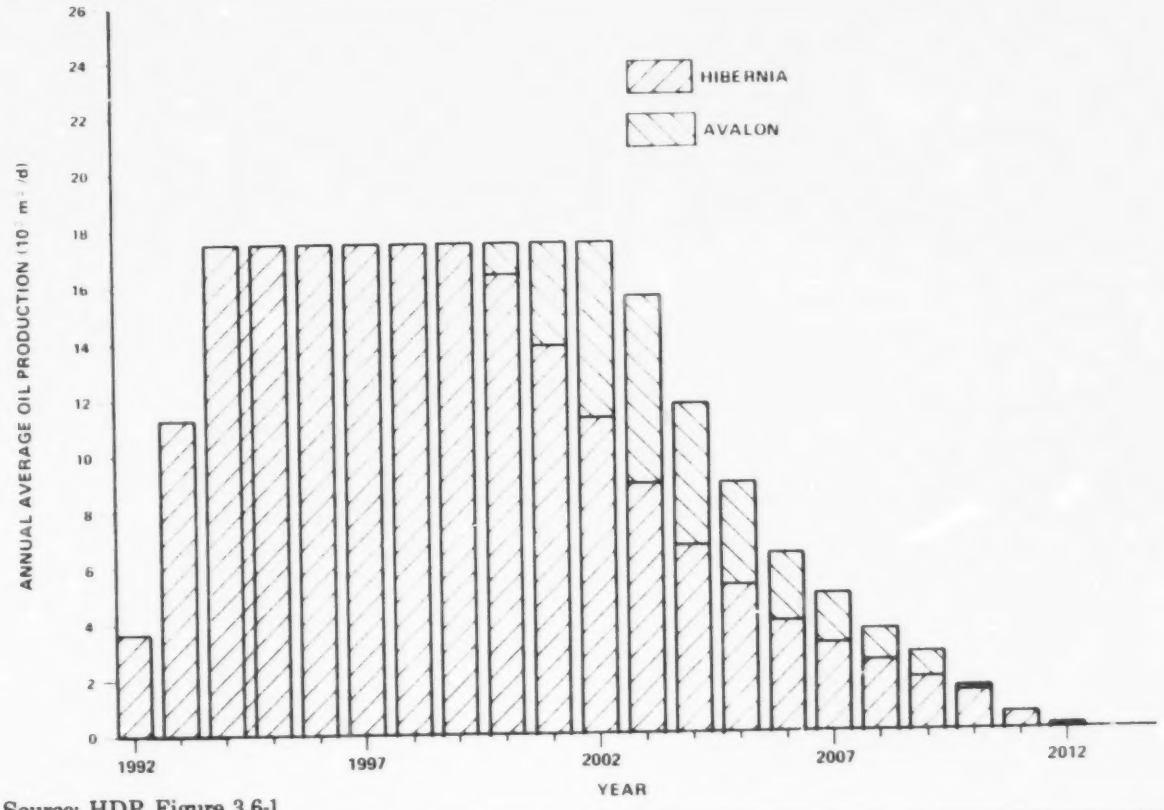
NA: Not available

For the Avalon Reservoir, areal reservoir simulation and semi-empirical studies as well as engineering judgement were used by NLPD to estimate the recovery factors. Recovery efficiencies obtained from the areal simulation studies ranged from 6 percent to 32 percent for the various regions and layers. Within the area of proposed Avalon development, the recovery factors ranged from 12 percent to 32 percent. Semi-empirical studies yielded recovery factors for layer 3 of the Avalon Reservoir from 8 to 28 percent and for layer 2 from 17 to 40 percent. To estimate reserves for both the Hibernia and Avalon Reservoirs, recovery factors were assigned to each fault block and layer.

Estimates of recoverable oil reserves for the Avalon and Hibernia Reservoirs and the recovery factors used are indicated in Table 3-7 and 3-8 respectively. NLPD also estimated natural gas liquid (NGL) reserves for the Hibernia Field to range from 13 x 10^6 m^3 to 24 x 10^6 m^3. No NGL reserves estimates were provided by the Proponent or COGLA.

Estimates of recoverable oil reserves have not been prepared by the Board. The Board accepts the procedures and methodology used by all three parties and observes that the discrepancies in reserves are a reflection of uncertainties related both to interpretation of the current data base and to expected production performance of the sandstones. More reliable recoverable reserve estimates can be made only after some production data are available. In the meantime, the range of reserve estimates presented in Table 3-7 provides an adequate basis for a Development Plan, and for this purpose, the Board accepts as representative the estimates presented by the Proponent.

Figure 3-15
Oil Production Forecast



Source: HDP, Figure 3.6-1

3.3.8
Oil Production Forecast

The Proponent prepared a forecast of average annual oil production based on likely reserves of 83 x 10^6 m^3 for the Hibernia Reservoir and for a possible future Avalon Reservoir development area. This forecast is shown in Figure 3-15. Production build-up will take two years with production commencing in 1992. It was assumed that each production well would contribute an annual average rate of 1,590 m^3/d with an overall operation efficiency of 90 percent. Because of uncertainties in reservoir performance and because less favourable reservoir quality areas will be drilled following the attainment of peak production, the well efficiency was estimated at 81 percent after the production build-up period.

The proponent estimated that, using these factors and engineering judgement, and allowing for interruptions in production for various reasons, an average annual production rate of 17.5 x 10^3 m^3/d could be expected for the Hibernia Sandstones. The Proponent further indicated that Avalon production could be initiated in the year 2000 to maintain the overall field production rate for an additional three years. Both the rate and point of production decline for the Avalon and Hibernia Sandstones were based on reservoir simulation studies.

The Board accepts the production forecast for the Hibernia Reservoir as representative of the approximate production levels that may be obtained from that reservoir. With regard to possible Avalon production, the Board observes that the levels shown on Figure 3-15 may be changed when a revised development plan is prepared by the Proponent, as per the Board's Condition 2.

3.3.9
Reservoir Management

The Proponent is planning to implement a comprehensive data acquisition program as part of a continuous reservoir management plan for the Hibernia and Avalon Sandstones to guide the development drilling and to optimize hydrocarbon recovery. This program will include reservoir performance monitoring and testing, coring, logging and fluid sampling programs. These data will be used to clarify areas of uncertainty. In addition, future reservoir model studies will be conducted after production data is available.

The Proponent stated that:

> "an important part of this program will be to match the actual field performance data collected during the early years of production with the performance predicted by the reservoir model. Once this match is obtained, future field performance can be more accurately predicted and reservoir development optimized."
>
> (HDP, Section 3.7).

The Board agrees with the Proponent's proposed Reservoir Management Program. The elements contained in the program adhere to sound reservoir engineering practices and conform with current legislation.

3.4
Physical Environment

In Chapter 4 of the Development Plan, the Proponent described the physical environment in the Hibernia Development Project area, and presented the meteorological, oceanographic and ice conditions for which the production system components will be designed.

Normal and extreme conditions have been estimated for storms, winds, visibility, ceiling, air temperature, precipitation, superstructure icing, bathymetry, waves, currents, tides, storm surges, sea temperature, salinity, turbidity, marine fouling, sea ice and icebergs.

The Proponent has emphasized the varying quality of the meteorological, oceanographic and ice data, and has allowed for this by using a 95 percent confidence limit, or other appropriate correction factors, in developing the normal and extreme conditions.

Three sources of meteorological observations were used in developing environmental parameters for the Hibernia area: the St. John's meteorological station, transient ships and drilling platforms. The St. John's weather data set was the prime resource because it contains high quality data accumulated over a long period of time. At the Hibernia wellsites, continuous environmental data were recorded from 1980 to 1984. Although five-year records are not reliable sources for determining extreme values, they are adequate for deriving frequency of occurrence statistics and have been used by the Proponent to study operating downtime due to environmental factors. The Hibernia wellsite data were used for air temperature, visibility, and wind speed and direction, while extreme values for various return periods were generated by hindcast analysis.

Oceanographic parameters such as current speed, current direction, wave height and wave period were routinely measured and recorded in the Hibernia area during the Proponent's drilling operations. In addition, an oceanographic survey over a large area of the Grand Banks was conducted during 1980 and 1981. Again, extreme values of waves and currents were estimated by hindcasting techniques.

The Proponent sponsored a number of programs to collect iceberg data including dimensions, mass, strength and impact properties. Observations of iceberg mass and velocity were routinely recorded during surveillance and towing operations in the drilling areas and historical data on iceberg occurrence and properties were obtained from the International Ice Patrol, Ice Central of Environment Canada and other organizations. Empirical modelling and random simulation techniques were used to determine iceberg impact forces and superstructure icing.

The Board notes that all environmental design parameters will be verified and accounted for in the review of the production system design by the Certifying Authority, and concludes that, generally, the physical environment description and parameter estimates submitted by the Proponent are acceptable for the present purposes. However, further documentation on the determination of design values for extreme wind speeds caused by mesoscale events and extreme iceberg impact loadings is required before these can be approved for design purposes.

The Board has also considered estimates of the extreme wave height in response to the Panel's recommendation concerning episodic waves (Panel recommendation # 25) that the GBS should be conservatively designed. The Board concludes, however, that the Proponent's approach in this regard is acceptable.

3.4.1
Extreme Winds

An estimate of extreme winds caused by mesoscale events is required to determine wind design criteria. For the Hibernia area, wind extremes were estimated by hindcasting techniques because long-term wind data are not available.

The Board notes that wind hindcasts are normally based on interpretation from historic charts of atmospheric pressure which are available for 6-hour intervals and over a large scale grid. Mesocale events, which by definition occur over a relatively short time span and distance, can be missed by pressure charts produced at such a large scale and long time interval. Therefore, short duration extreme winds may be underestimated. These shorter time-averaged extremes are important in the design of certain parts of the topside production facilities and the ALPs.

The Proponent indicated that it plans to conduct further studies to estimate the extreme three-second gust and one-minute mean caused by mesoscale events. These values will then be used as design parameters for the production facilities, if the resulting values are higher than the hindcast values presented in the Development Plan.

The Board agrees that further study should be conducted on the estimation of extreme winds caused by mesoscale events. The Board will seek advice regarding an appropriate methodology from the Atmospheric Environment Service (AES) of Environment Canada. As well, the Board will ensure that the Certifying Authority verifies and accounts for these values in the design, as appropriate.

CONDITION 4

It is a condition of the approval of the Hibernia Development Plan that the Proponent conduct a study on the estimation of extreme winds caused by mesoscale events and submit the results of the study to the Board prior to using them for design purposes.

3.4.2
Extreme Iceberg Impact Loadings

The Proponent has stated in its studies that statistically generated properties of specific icebergs such as mass, velocity, shape and impact strength were used to represent impact loads at key elevations of the GBS structure. Using these data, the preliminary design of the GBS allows the structure to resist the maximum loading imposed by the 500-year return period iceberg event. The Proponent expects that these design calculations will be verified by regulatory agencies.

The Proponent has also stated that

> "the ALP will withstand all environmental conditions anticipated at Hibernia with the possible exception of impact by a large ice mass. The probability of such an occurrence will be minimized through ice management techniques. . . . . In the unlikely event of a direct iceberg impact, the ALP might be damaged or rendered inoperable"
>
> (HDP, Section 6.5.2).

At the Panel hearings, the Department of Fisheries and Oceans expressed concern about the ability of the GBS to withstand impacts from bergy bits and growlers which can move at relatively high velocities under storm conditions.

The Panel concluded that, although it was probable that an iceberg mass would collide with the GBS during the life of the project, it was satisfied that the proposed design was capable of withstanding such an event. However, the Panel also felt it was reasonable to expect that the ALPs could be seriously damaged by extreme ice conditions. The Panel, therefore, recommended that ALP's be designed to ensure that oil spills are avoided in the event of failure of system components or the structure itself (Panel recommendation # 22).

The Board is satisfied that adequate compensation for the loading imposed on the GBS by icebergs will be made at the detailed design stage. To complete its assessment of the preliminary loading estimates, the Board will require additional information on the methodology and the data used to estimate iceberg impact loads. The Board will also ensure that the Certifying Authority undertakes a critical review of these values.

The Board concurs with the Panel's conclusion regarding the possibility of damage to the ALPs and agrees that it is necessary for the Board to ensure that the designs and contingency plans to be submitted make adequate provision for minimizing the risk of oil spillage in the event of damage due to icebergs or other events. The Board's requirements on these matters are reported in its decisions concerning iceberg scour in Section 3.8.2 and contingency plans in Section 3.9.4.

3.4.3
Wave Parameters

Various wave parameters such as episodic waves, groupiness, steepness, breaking waves and extreme waves must be taken into account in the design of the facilities, as appropriate.

The Proponent has stated that the GBS and the ALP will be designed to withstand all wave-generated loadings. The effects of wave grouping, which is the tendency of large waves to occur consecutively, have been considered in the estimation of the extreme wave height but should not otherwise affect the fixed production platform for Hibernia. The Proponent has also stated that the extreme wave analysis was performed on a sufficient storm population to produce reliable results when including a design safety factor.

Several intervenors at the EIS hearings expressed concern that the values of certain wave parameters may be underestimated for the GBS design, particularly with respect to episodic waves, breaking waves and groupiness.

There was further concern that there were statistical and methodological inadequacies with the model and the techniques employed for estimating extreme wave heights and that the most appropriate storm population had not been selected to hindcast extreme waves.

However, after reviewing the EIS Supplementary Information, the Panel concluded that the perceived wave climate deficiencies had been treated satisfactorily. The Panel recommended that the structure should be conservatively designed to allow for the possibility of episodic waves (Panel recommendation # 25).

The Board is satisfied with the statistical approach taken by the Proponent. This approach utilizes an acceptable wave population distribution to estimate the 100-year return period wave height. The extreme wave includes any "episodic" waves which may occur within that time period. The 100-year return period criterion has been applied successfully for design purposes in other jurisdictions.

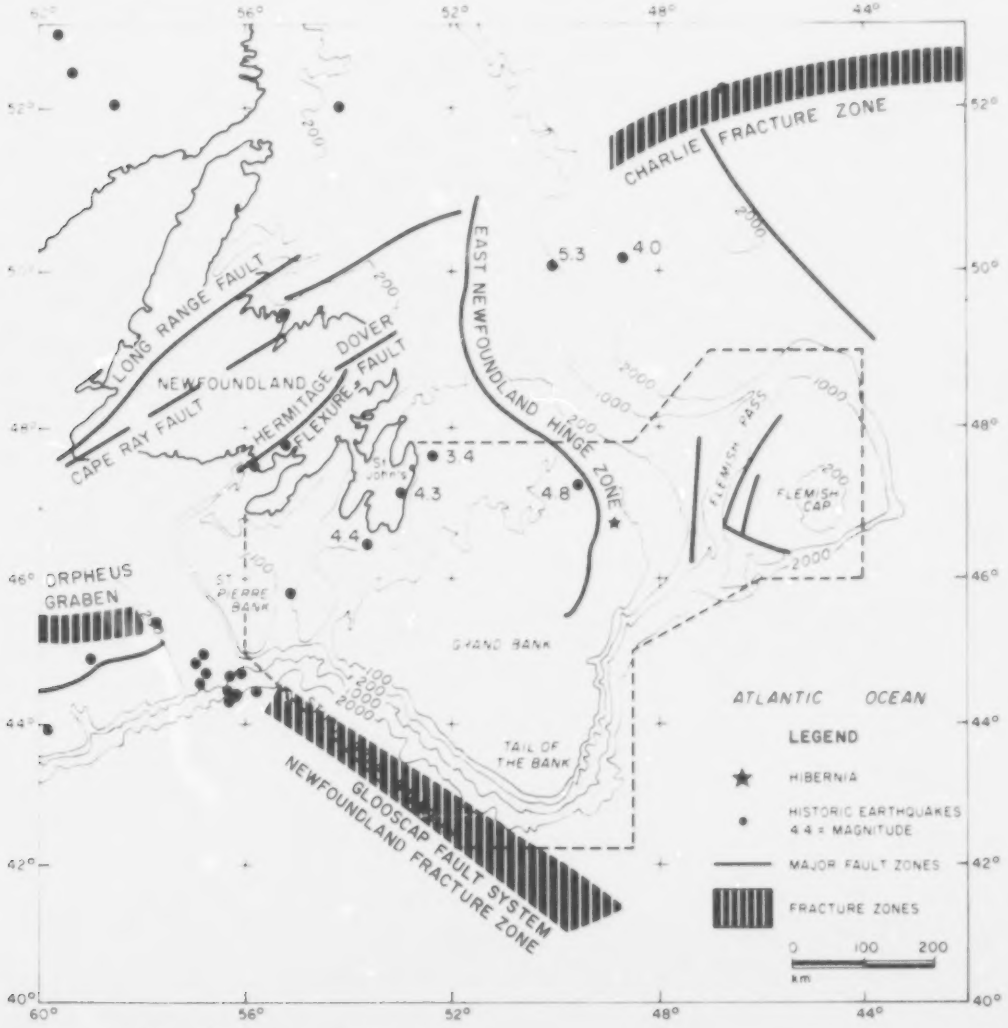
The Board is satisfied that the issues dealing with the remaining wave parameters have been adequately addressed. The Board will ensure that the Certifying Authority verifies and accounts for all wave parameters in reviewing the design, as appropriate.

3.5
Geotechnical Engineering

In Chapter 5 of the Development Plan, the Proponent presented geotechnical information obtained from field and laboratory investigation of soil samples taken in the Hibernia area. The investigations were reported to include a soil boring program in 1983 (HDP, Section 5.2.1) with cone penetration and piezocone penetration tests at various depths in the boreholes. The recovered samples were tested in the laboratory to determine their strength, compressibility and cyclic loading characteristics. A geophysical survey was also carried out in 1983 (HDP, Section 5.2.2) to define the bathymetry and seabed geological features. The Proponent used this information in the preliminary design of the facilities.

Data from various surveys—pipeline reconnaisance, wellsite and regional (Bedford Institute of Oceanography and Centre for Cold Ocean Resources Engineering)—were analyzed to provide a catalogue of iceberg scours for the Hibernia site (HDP, Section 5.2.3). The Proponent stated that it proposed to conduct site-specific geophysical and geotechnical investigations to provide information for the detailed design.

Figure 3-16
Major Tectonic Features and Seismicity of the Hibernia Area.



Source: EIS, Volume IIIa, Figure 3.1-52

The Proponent proposes to locate the GBS platform at 46° 45' 50"N, 48° 45' 35"W in a water depth of 80 metres with a seabed slope of about 0.5° and a relief of about 0.5 metres (HDP, Section 5.3) and reported that at that location, a thin layer of surficial sediments was found to overlay 50 to 60 metres of dense sand with thin, hard clay layers. Below this, cohesive soils occurred with sand layers (HDP, Section 5.4.1; EIS, v. II, 3.3.4). Seabed features near the offshore facilities included megaripples, iceberg scour and linear furrows but there was no evidence of shallow faults, submarine slides and shallow gas accumulations.

The Proponent defined the Grand Bank seismotectonic province (Figure 3-16) as a triangular area bounded on the south by the Glooscap—Newfoundland Fracture Zone, on the east by the North American Continent—Atlantic Ocean Contact and on the northwest by the Cabot—Long Range fault system and the Hermitage Flexure—Charlie Fracture zone (EIS, v. IIIa, 3.1.4.4). The Proponent has used two different levels of extreme ground motion criteria, operating level and safety level earthquakes, for the design of the facilities. The facilities would withstand an operating level earthquake without damage whereas the safety level earthquake would damage the facility but would not cause progressive collapse.

A return period of 200 years was used to define the operating level earthquake. The estimated ground motions associated with this event were an acceleration of 30 cm/sec^2 and peak ground velocity of 3 cm/sec. For the safety level earthquake, a magnitude 5.5 earthquake 20 kilometres from the facilities site and a magnitude 7.25 earthquake 520 kilometres from the facilities site were considered. The peak ground motions associated with those earthquakes corresponded to an acceleration of 98 cm/sec^2 and velocity of 18 cm/sec (HDP, Section 5.5.1).

The Proponent has stated that expected low level earthquake intensity and dense soils at the facilities site preclude any danger of soil liquefaction (EIS Supplement, Sept. 15, 1985, 2.5.2.2) and sediment transport was not expected to affect the design (HDP, Section 5.5.3). The settlements were estimated to be small and were not expected to exceed 0.3 metres during the life of the platform.

The Board considers that the geotechnical considerations were generally well handled and the additional work needed to support the detailed design was clearly identified. However, the following three aspects warrant greater consideration:

- Site specific investigation
- Design iceberg scour depth
- Seismic design criteria

3.5.1
Geotechnical and Geophysical Site Investigation

The Department of Energy, Mines and Resources (EMR), in its submission to the Panel, expressed concern regarding the stability of the seabed that would support bottom-founded installations and recommended that the Proponent undertake a geotechnical survey to characterize the foundation sediments when a development site has been chosen and specify measures to mitigate possible sediment failure under a GBS.

The Panel recommended that the results of ongoing studies on seabed stability should be incorporated into the design of the GBS and other offshore components." (Panel recommendation # 26).

The Proponent stated that it proposed to conduct a site-specific geotechnical investigation and a closely spaced, high-resolution geophysical survey over the development area of the Hibernia Field for final design of the facilities (HDP, Sections 5.2.2 and 5.6).

The Board notes that the Proponent has applied for and received the Board's approval to conduct a geotechnical investigation involving a soil boring program including coring up to 100 metres, piezocone penetration tests, and a geophysical investigation involving high resolution, shallow seismic and side scan surveys. Progress reports on the results of this program are to be submitted to the Board.

The Board has concluded that the geotechnical site investigation currently proposed by the Proponent is adequate.

3.5.2
Iceberg Scour Design Criteria

When icebergs contact the seafloor, they create depressions (scours) and the soil below the depression is disturbed to some extent. The energy associated with these contacts is large and any facility or equipment that needs to remain functional after being subjected to such a disturbance should be located below the depth of the disturbance. To design such systems, the design depth for iceberg scour disturbance must be determined.

The Proponent has indicated that

> "scour records will be used with scour prediction models to assess iceberg scour when planning installation of a subsea production system in later years of development"
>
> (HDP, Section 5.4.3).

The Proponent also stated that should subsea equipment or flowlines be damaged by icebergs, they would be repaired or replaced, and that

> " maximum scour depths as anticipated from acoustic records may not be equivalent to the original scour depth due to uncertainties associated with acoustic measurements and/or partial infilling."
>
> (HDP, Section 6.4)

The maximum scour depth measured in the Hibernia area was reported to be 1.6 metres; however, a 10 metre pit was found 12 kilometres east of the proposed GBS location. The Proponent suggested that the age of the iceberg scours and pits was unknown and that the measured depths may not reflect recent scour activity. (HDP, Section 5.4.3)

EMR, in its submission to the Panel, recommended that further studies be conducted because the observed scour depths may be less than the depth of the scour at the time of its formation, as a result of a variety of factors such as infilling.

The Department of Fisheries and Oceans (DFO), in its submission to the Panel, stated that while it recognized the cost of protecting seabed components of the project from iceberg scour and resulting damage leading to loss of fluids, costs should not be the only factor in deciding whether or not to protect the components. It recommended that protection of seabed components be a condition of project approval.

The Panel concluded that, as it is likely that an unprotected pipeline, production manifold or wellhead would be damaged by iceberg impact, a conservative protective approach should be taken to prevent oil spills. The Panel, therefore, recommended complete protection of subsea components, by measures such as burial. (Panel recommendation # 23).

The Board recognizes that available information is not adequate to determine the design iceberg scour depth and has assessed this issue in two phases: i) the installation and operation of the export lines from the GBS to the loading platforms, and ii) the installation and operation of subsea wells, flowlines and manifolds.

While the design iceberg scour depth has not yet been determined, it is probable that the export line would be damaged if subjected to iceberg contact. The Proponent has indicated during the EIS hearings that the export line will be flushed when icebergs threaten the line. It is necessary, therefore, to design the facilities to permit effective flushing and to develop contingency plans that take possible damage from iceberg contact into account. The Board's views concerning contingency plans and its decision thereon are reported in Section 3.9.4.

CONDITION 5

It is a condition of the approval of the Hibernia Development Plan that:

(i) the Proponent design the export lines and loading platforms so that they can be flushed of hydrocarbons if there is risk of damage to those facilities, and

(ii) the design iceberg scour depth be determined by the Proponent and approved by the Board prior to the design of subsea installations.

3.5.3
Seismic Design Criteria

The effects of earthquakes must be considered in the design of structures to be located in areas that are determined to be seismically active. An area is considered seismically active on the basis of its record of previous earthquake activity in both frequency of occurrence and magnitude. For areas where detailed information on seismic activity is not available, the seismicity is determined on the basis of technical investigations, including a study of the geological history and seismic events in the region.

The Proponent adopted two conditions of seismicity for preliminary design purposes, the operating level earthquake and the safety level earthquake. The Proponent has stated that the seismic criteria were not expected to govern the global design of the GBS but might have an effect on the design of certain topside equipment.

The Proponent obtained the operating level earthquake using probabilistic models based on a return period of 200 years. The probability model was consistent with the methodology used in developing the new seismic zoning map for the 1985 edition of the National Building Code of Canada. The safety level earthquake was chosen based on previous large earthquakes in the region.

The Proponent has stated that recent studies by EMR investigating the use of earthquake models for the east coast and future studies will be monitored for their possible application in refining data for the Hibernia area (HDP, Section 5.5.1).

EMR in its submission to the Panel stated that seismicity assessment was poorly treated by the Proponent, being based on a study prepared in 1981. The EMR submission stated that there have been a number of important developments relevant to the determination of seismic hazards in the eastern Canadian offshore. These include:

- the development of the zoning maps for 1985 edition of the National Building Code,
- internal research by EMR staff,
- the development of the CSA Standard for the design, construction and installation of fixed offshore structures which includes the manner in which seismic risk is to be handled.

EMR, therefore, recommended that seismicity of the Hibernia area be reassessed. EMR has indicated, in a communication to COGLA, that the probability (0.001/yr.) exists that the far field event assumed by the Proponent could occur at a much closer distance than that proposed by the Proponent. Consequently, EMR recommended that a probabilistic approach be used for the safety level earthquake evaluation and that the regulator specify the probability level for this event.

The Panel recommended that the results of ongoing studies on seismicity be incorporated into the design of the GBS and other offshore components. (Panel recommendation # 26).

The Board notes that the approach taken by the Proponent in defining the operating level earthquake and the safety level earthquake is consistent with general offshore practice. However, the seismic design criteria were based on a 1981 study and since that time additional work has been done on seismic risk in the eastern Canadian Continental Margin. The Board also notes that various models have been developed to describe the zones where earthquakes might occur. One of EMR's models, which assumed that earthquakes need not be confined to areas of historic seismicity, indicated that a magnitude 7 earthquake could occur much closer than the far field safety level earthquake (magnitude 7.25 earthquake at 520 kilometres) stated as a design criterion by the Proponent.

The Board concludes that the seismic design criteria should be re-evaluated taking into consideration the research that has taken place in recent years and will ensure that the Certifying Authority considers the seismic design criteria in its review of the design.

CONDITION 6

It is a condition of the approval of the Hibernia Development Plan that the Proponent re-evaluate the seismic design criteria taking into account the recent and ongoing studies related to seismic risk on the eastern Canadian Continental Shelf, and submit the results of this re-evaluation to the Board for approval prior to using the results of the study for design purposes.

3.6
Production and Transportation Systems

In Chapter 6 of the Development Plan, the Proponent described the production system which it proposed would consist of a fixed production platform of topside facilities mounted on a gravity base structure (GBS) utilizing both platform and subsea wells. The transportation system would consist of an export pipeline, two articulated loading platforms (ALPs) and three purpose-built shuttle tankers. The production and transportation systems are described in more detail in Appendix D entitled "Hibernia Development Plan Overview".

The GBS will consist of three components; a concrete base raft, a caisson reaching from the seabed to approximately 5 metres above mean low water level and four shafts extending above the caisson to support the topside facilities. Table 3-9 provides a comparison of the approximate dimensions and capacities of the Hibernia platform with those of several North Sea platforms. The Hibernia GBS caisson will incorporate a heavy outer wall, known as an ice belt, which is not found on North Sea platforms. In addition, the extension of the caisson above mean low water level, is not a common feature of North Sea platforms although a version of the extended caisson exists in the Ekofisk Tank and two platforms in the Frigg field.

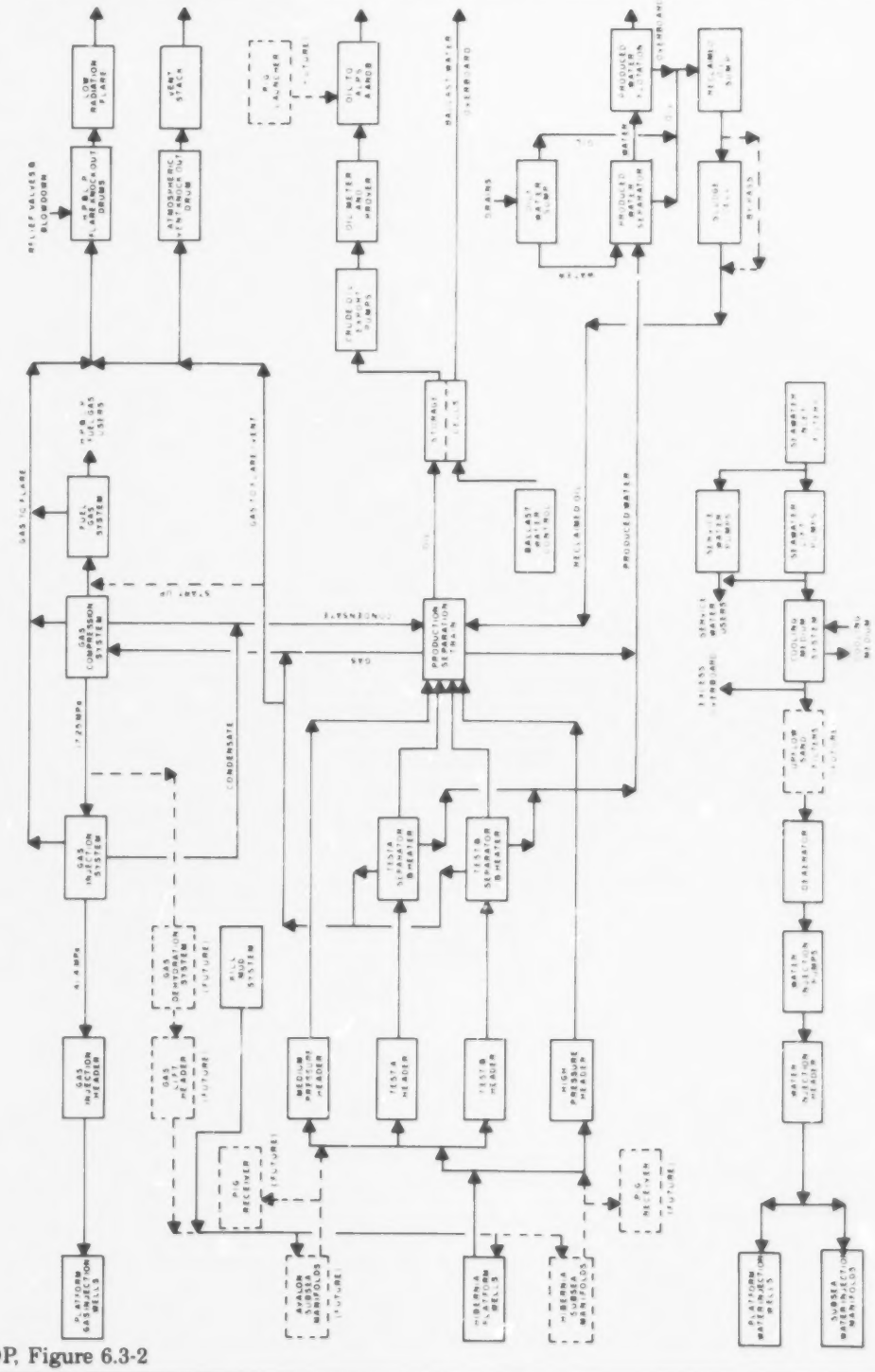
The topside facilities consist of three levels, the cellar deck, the module deck and the weather deck, and will incorporate process, utility, drilling, electrical and personnel support systems. The process facilities will allow for three-stage oil separation, gas compression, fuel gas, and relief and flare systems. Figure 3-17 is a block flow diagram for the proposed process system.

The Proponent stated that all components of the production system would be equipped with comprehensive safety systems to monitor the production process and ensure that operating parameters are maintained within safe limits. When activated, the safety systems will shut down or otherwise initiate appropriate control of the process. Safety systems will include fire suppression, fire and gas detection, emergency shutdown, well control, ventilation and alarm annunciation.

Table 3-9
Comparison of Platform Dimensions and Capacities

	Beryl A	Statfjord A	Statfjord B	Hibernia
Production Capacity (bpd)	150,000	330,000	180,000	151,000
Oil storage capacity (barrels)	900,000	1,300,000	1,900,000	1,447,000
Living quarter capacity (beds)	120	200	200	200
(expanded to)	200			
Water depth (m)	120	145	145	80
Critical wave height (m)	20	30	31	29.3
Distance between sea and deck (m)	23.5	28	29	29.5
Shaft height above cells (m)	90	106	111	20
Cell height (m)	50	67	64	85
Deck cross-sectional area (m × m)	71 × 60	83 × 86	114 × 55	75 × 75
Gravity base structure base area (m^2)	8,200	9,500	18,200	7,900
Amount of concrete (m^3)	53,000	87,000	134,000	156,300
Deck weight without outfitting (tonnes)	5,900	9,500	7,500	6,500
Dry weight of outfitted deck (tonnes)	19,400	37,300	35,000	36,000
Fully outfitted wet deck weight (tonnes)		46,400	49,600	48,000
(maximum)				51,000
Total weight (tonnes)	350,000	650,000	816,000	1,182,600
Number of shafts	3	3	4	4
Number of oil storage cells	16	15	20	28
Number of wells	40	42	42	64
Number of drilling rigs	2	1	1	2
Number of deck modules	0	19	10	16

Figure 3-17
Process Facilities Block Flow Diagram



Source: HDP, Figure 6.3-2

Routine emissions from production operations are described to include produced water, waste water, and exhaust gas. Sanitary and domestic wastes will occur as emissions from each staffed installation. Table 3-10 lists the routine discharges estimated for the project. The governmental standards listed in this table are representative of draft guidelines currently being developed and conform with existing government regulations.

It is anticipated that a Certificate of Fitness will be issued to the Proponent by a Certifying Authority licensed by the Board. This Certificate will contain those operational limitations which the Authority deems necessary. The Proponent intends to contract the services of the Certifying Authority prior to the design phase of the project so that design criteria may be assessed before detailed design starts.

The Production Installation Regulations (now in draft form) state that the Certifying Authority may not issue a Certificate of Fitness unless it is satisfied that:

- the production installation has been installed at the planned location;
- the production installation has been designed, constructed, transported, installed and maintained in accordance with the requirements of The Production Installation Regulations and The Production and Conservation Regulations; and
- in any respect not covered by the Regulations, the production installation is fit for the purpose for which it is to be used.

The Proponent will be obliged to provide the Certifying Authority with any information that the Authority may require in order to issue the Certificate of Fitness, or to evaluate the quality assurance and quality control programs, operations manuals and contingency plans, inspection and monitoring program, maintenance program, or weight control program. Also, the Proponent will be obliged, at the request of the Authority, to carry out or permit and assist the Authority to carry out required inspections, tests or surveys of the production installation.

The Regulations stipulate that before the Certifying Authority issues a Certificate of Fitness, the Authority and the Proponent will be required jointly to certify to the Board that they have agreed on a plan for the periodic inspection of the production installation by the Authority that is adequate to provide reasonable assurance of the continuing integrity, serviceability and safety of every critical component of the production installation.

The Board is satisfied, generally, with the Proponent's proposals. However, the following aspects of the system require more particular attention:

- Flaring of natural gas
- Disposal of produced water
- Treatment and disposal of storage displacement water
- Subsea installations design parameters
- Decommissioning/abandonment
- Evacuation systems

3.6.1

Flaring of Natural Gas

The flaring of natural gas is not good resource conservation practice. The Board's decision on flaring of natural gas has been given in Condition 3.

3.6.2

Disposal of Produced Water

The level of treatment and method of disposal of produced water determine its impact on the marine biota. Subsequent to the breakthrough of injection water into the producing wellbores, which could occur at any time during production, chemicals used to treat injection water, such as biocides, anticorrosives, or oxygen scavengers, will likely appear in any produced water which is discharged into the marine environment. The depth at which the discharges are made will influence effluent dispersion.

The Proponent has indicated that produced water from the separators and coalescers will be pumped to the produced water separators where gas flotation units will be used to remove oil to compliance levels. The treated water will be continuously discharged overboard via the sea-water return line. The Proponent also stated that discharge of wastes (including produced water) below the summer thermocline would be feasible (Panel report, p. 32).

Table 3-10
Liquid and Solid Effluents; Fixed Production System Operations

Effluent	Frequency Of Release	Quantity/ Rate of Discharge (1)	Physical Characteristics	Chemical Characteristics	Control/ Treatment Method	Discharge Point	Governmental Standard
Produced water	Continuous	14.3 x 10^3 m^3/d max. from GBS	65°C pH 5.6-7.0	15-40 mg/L total oil; 100-400 mg/L during upset; 5-10 mg/L aromatic; 135 000 mg/L(2) total dissolved solids 600-1 600 mg/L TOC	Tilted plate separator or air floatation unit as needed to meet standards	Below surface from GBS	35 mg/L
Storage displacement water	Intermittent	32 x 10^3 m^3/d max.	Same as seawater	10-35 mg/L total oil; seawater	No treatment	Below surface from GBS	
Tanker ballast	Contingency only; batch discharge	8 x 10^3 m^3	Seawater		Segregated ballast tanks		
Tanker bilge	Intermittent	< 10 m^3/d	Water or oily water		Bilge treatment	Subsurface	
Cooling water	Continuous	180 x 10^3 m^3/d max. without injection; 130 x 10^3 m^3/d with max. injection.	$\Delta T \leq 30°C$	1-2 mg/L residual chlorine max.		Below surface from GBS	

Note (1): Up to 2 semisubmersible drilling/workover rigs may be in the field.
(2): Based on a limited number of formation water samples.

Table continues on following page

Table 3-10; Continued
Liquid and Solid Effluents; Fixed Production System Operations

Minor Wastes							
Deck drainage (open drains)	Intermittent	150 m^3/d max; no separate discharge		Crude, hydraulic, lube oils; detergents; solvents	Combined with produced water system and treated	With produced water	
Well work-over and stimulation fluids	Occasional; once every 2-5 years for each well	50-100 m^3 per well	Variable	Spent HCl or HF acid; dissolved salts	Return through produced water treatment system	With produced water	
Produced sand	Daily; Occasional	<1 m^3/d; Several m^3		Sand and silt; Oily sand and silt	Flushed out of produced water treatment system	With produced water to shore for disposal	
Sanitary waste	Continuous	40 m^3/d		<50 mg/L BOD; < 78 mg/L suspended solids; 1 mg/L residual chlorine	Aerobic treatment	Subsea discharge from GBS	max 50 mg/L BOD; max 75 mg/L sewage; <10% suspended solids; max 400 per 100 mL fecal coliforms
Domestic waste	Continuous	78 m^3/d		200 mg/L BOD; 50 mg/L BOD suspended solids		Subsea discharge from GBS	
Oil processing wastes	Intermittent	No discharge		Refined oils	Collected in sumps; oil to process		
Sludges	Occasional cleanout	Variable		Emulsified crude and solids, rust, scale	Containerize	To shore for disposal	
Solid wastes/ debris	Routine			Kitchen wastes; paper wastes; metal wastes	Paper waste incinerated; wet garbage bagged	To shore for disposal	
Subsea facility releases	Continual low-level	<1 m^3/d		Biodegradeable hydraulic fluid	None	Subsurface	
Desalination brine		10-20 m^3/d	Concentrated seawater				
Excess seawater Excess injection water	Occasional	Variable		1-2 mg/L residual chlorine; oxygen scavenger; scale inhibitor; biocide		GBS	
Minor leaks/ small loading spills	Occasional	0.005-0.1 m^3(*)		Crude oil, deisel		Sea surface	

(*): Institute of Offshore Engineering (1983).

Source: EIS, Volume IIIb, Figure 4.3-4.

One alternative to the discharge of produced water overboard is reinjection into the reservoir structure or into another formation dedicated to this purpose. During the Panel hearings, several intervenors, including DFO and Environment Canada, recommended that the Proponent consider reinjection of produced water into the reservoir formation. Failing this, overboard discharge of produced water below the thermocline was suggested in order to mitigate the impact on marine biota. At the same hearings, the Proponent stated, in response to an intervention by DFO, that reinjection of produced water was under consideration as an alternative to discharge (Panel report, p. 32). However, this alternative was not discussed in the Development Plan.

The Panel recommended that reinjection of produced water be implemented during the project (Panel recommendation # 31).

The Board notes the concern about discharging produced water into the marine environment, particularly after injection water, with its added chemicals, breaks through. The Board also notes that effluent discharges must comply with regulations existing at the time of production and has concluded that any produced water which is discharged should be released below the summer thermocline.

The Board is concerned about the discharge of toxic chemicals into the environment and is aware that the institution of a program categorizing all chemicals used on offshore installations according to their toxicity has worked effectively in other jurisdictions to deal with this problem. Such programs called 'chemical notification schemes' require the development of approved lists of chemicals from which operators must choose those they wish to use and, subsequently, report to the regulator details of their usage. Programs of this nature have been required for hydrocarbon exploration and production in the North Sea and in Canadian waters north of 60°.

The Board concludes that, because of the reliance of Newfoundland on a healthy marine environment, it would be prudent to institute a similar scheme for the area under its jurisdiction. The Board, therefore, intends to consult with the Proponent and appropriate environmental agencies concerning the institution of such a program.

The Board notes that in other offshore jurisdictions, reinjection of produced water is usually required only in nearshore areas or in areas of acute biological sensitivity. The Proponent has stated that it is considering the reinjection of produced water. The Board has concluded that sufficient grounds do not exist at this time to require the Proponent to reinject produced water.

However, since produced water is not to be reinjected immediately, it must be the focus of a rigorous and broadly based environmental effects monitoring program. In the light of this, it is necessary that the Proponent provide in the design of facilities for the possibility that it might be necessary to install, at some future date, equipment to mitigate an unacceptable environmental impact disclosed by the effects monitoring program. The Board's views and discussions concerning effects monitoring are reported in Section 3.9.1.

CONDITION 7

It is a condition of the approval of the Hibernia Development Plan that:

i) **produced water which is intended to be discharged be treated to comply with the regulatory requirements existing at the time; and**

ii) **before finalizing the design of facilities the Proponent submit for the Board's approval a plan for the reinjection of produced water in the event that the effects monitoring program should disclose unacceptable environmental damage resulting from that source.**

3.6.3
Treatment and Disposal of Storage Displacement Water

The Proponent has been inconsistent in the statements it has made regarding its intention to treat displacement water before it is discharged into the environment. Clarification is also needed regarding the depth at which the discharge is to be made as this factor may affect the impact on the biota.

The Proponent has indicated that it will treat waste fluids associated with operation and maintenance to comply with the guidelines for quality of operational effluent discharges which are presently being developed (HDP, Section 9.5.1). In the EIS (vol. IIIb, p. 44), the Proponent stated that storage displacement water will contain between 10 and 35 milligrams per litre of total oil and that this will be discharged without treatment. In the Development Plan, the Proponent stated that storage ballast water will be discharged into the ocean and no prior treatment was proposed (HDP, Section 6.2.3). However, at the Panel hearings, the Proponent indicated that storage water will be treated before being discharged (Panel report, p. 32). At the same hearings, the Proponent also stated that the discharge of fluids below the summer thermocline would be feasible.

In its intervention at the Panel hearings, Environment Canada suggested injecting wastes, including storage displacement water, into the reservoir structure. DFO also expressed concern that the effects of the discharge of storage displacement water on pelagic organisms could be substantial and cumulative. The Panel recommended treatment of storage displacement water and discharge below the summer thermocline (Panel recommendation # 31).

The Board notes that prior to production it is difficult to predict the amount of oil which may be in storage displacement water discharge streams. Therefore, facilities design should include provision for the treatment of storage displacement water should this become necessary in order to comply with the regulatory requirements existing at that time. Similarly, if it is possible to discharge waste waters below the summer thermocline (and the Proponent has stated that it is), then they should be discharged at that level. Because it is not always possible to predict accurately impacts of waste waters on the marine environment, this should become an integral part of an effects monitoring program. The Board's views and decisions regarding effects monitoring are reported in Section 3.9.1.

CONDITION 8

It is a condition of the approval of the Hibernia Development Plan that:

i) the Proponent allow in its design for the facilities to treat storage displacement water should treatment become necessary; and

ii) the Proponent design its facilities so that fluid discharges will occur below the summer thermocline.

3.6.4

Subsea Installations Design Parameters

The Proponent has proposed to drill a number of subsea production and water injection wells in locations beyond the practical range of directional drilling from the platform. Subsea wells would be located on or below the sea floor and would be tied into the GBS through subsea gathering lines, production manifolds, and individual subsea flowlines. Production from subsea wells would not be required until later in the production life of the project.

The subsea installations may be subject to damage by trawl boards, anchors or icebergs. The Proponent has stated that such damage would be repaired or installations replaced, that operational procedures would be developed to minimize environmental risk and that wells would be able to maintain pressure integrity in the event of damage.

The Board accepts the concept that subsea installations are required for efficient development of the field and notes that detailed engineering for subsea installations is scheduled to start in 1992. Therefore, the Board can give only conceptual approval at this time.

The Board also notes information on subsea pipelines and manifold design parameters will be required to support an application for approval to construct a pipeline and that information on subsea wellhead design parameters including iceberg scour depth will be required to support an application for drilling plan approval.

CONDITION 9

It is a condition of the approval of the Hibernia Development Plan that the Proponent obtain specific approval from the Board for its plans for subsea installations prior to proceeding with the detailed design of these facilities.

3.6.5

Decommissioning/Abandonment

Provision should be made in the design of offshore installations to allow for their eventual disposition. The Proponent has indicated that

> " when the reserves of the Hibernia Field have been recovered, decommissioning and site restoration will be carried out in accordance with applicable regulations at that time . . . any decommissioning procedures formulated now would only be speculative."
>
> (HDP, Section 6.6).

Abandonment of the platform

> "would involve removal of equipment items which could be economically used elsewhere. A plan for the abandonment of the structure itself would be developed in compliance with all government regulations which may prevail. The ALP column and head assembly would be recovered and transported either to another development project or to shore for dismantling. The ALP base structure would be left in its offshore location".
>
> (EIS, v. II, 8.3)

> "The wells would be abandoned by installing cement plugs and mechanical bridge plugs, and removing all equipment above the seafloor."
>
> (HDP, Section 6.6).

> "Flowlines, gathering lines, export lines, and production manifolds would be flushed out, disconnected, and the open ends capped. The production manifolds would be either abandoned in their seabed locations or recovered and taken to shore".
>
> (EIS, v. II, 8.2)

DFO, in its submission to the Panel, expressed concern that the seabed within the project exclusion zone may not be fully restored at abandonment. The concern was based on the lack of a stated commitment to recover or bury all sub-sea components. There was a fear that if the Hibernia exclusion zone were not restored to a fishable condition, a precedent would be established that could result in unacceptable losses if additional fields were developed. The department, therefore, recommended that the project exclusion zone be returned to a fishable condition.

Other groups echoed the above concerns and the Panel recommended that the entire development area be restored to a fishable condition upon abandonment of the project. (Panel recommendation # 38).

The Panel also concluded that although there may be temporary advantages to the use of the GBS for navigation, rescue or other purposes after completion of the Hibernia Project, long-term deterioration of the structure may require continual maintenance or eventual removal if it is not to become a hazard. The Panel, therefore, recommended that the GBS be designed in such a way that it could be refloated and removed if necessary. (Panel recommendation # 39).

The Board is aware of the costs involved in removing the massive platforms required for hydrocarbon production in deep waters and hostile regions. Currently, the United Nations Convention on the Law of the Sea, to which Canada is a signatory, does not explicitly require the complete removal of offshore stuructures. With the prospect of some of the North Sea platforms ceasing production in the next decade, governments and industry are trying to develop a mutually acceptable regulatory regime.

It is recognized that international practice concerning the requirement for the removal of abandoned platforms will be more definitive by the time the Hibernia GBS is to be abandoned, than it is at present. However, failing to provide in the design for eventual removal would increase the complexity and costs of so doing, if a decision to remove the facilities were to be made by the Authorities of the day.

Removal of ALP bases, manifolds and field pipelines does not pose as large a problem as removing the GBS. However, in the interest of efficiency, provision for the eventual removal of subsea facilities should be considered during their design.

Alternatively, these facilities should be installed so that they could be covered and not pose a threat to fishing gear.

CONDITION 10

It is a condition of the approval of the Hibernia Development Plan that the Proponent design all subsea facilities such that, upon termination of production, they will be capable of being covered or removed so that the area is returned to a fishable condition, and design the GBS so that it could be removed if the Authorities at that time so require.

3.6.6
Evacuation Systems

Since the loss of the *Ocean Ranger*, the adequacy of evacuation systems installed on offshore facilities has been in question. The issue was considered by the Royal Commission on the *Ocean Ranger* Marine Disaster and was an issue during the public hearings held by the Panel. The Panel recommended that functional project evacuation systems be provided prior to production commencement. (Panel recommendation # 41).

The Proponent has stated that one or more muster stations for platform abandonment will be strategically located within the topside facilities and that muster stations will be accessible by at least two routes.

> "Totally enclosed lifeboats for 200 percent of the number of beds on the facility and liferaft capacity for 100 percent will be provided. Approved abandonment suits for 200 percent of the personnel will be provided; half of these will be located in the accommodation facilities, and the other half at the lifeboat muster stations. Lifeboats may be supplemented by a dry evacuation system for which general concepts are being studied in the North Sea by Mobil".
>
> (HDP, Section 6.7.1).

The Production Installations Regulations (currently in draft form) require in Section 3.15, under "Lifesaving Equipment" that:

> "Every manned production installation be equipped with lifesaving equipment capable of evacuating personnel from the installation under all foreseeable environmental and operating conditions".

And in Section 3.17(1), under "Means of Escape" that:

> "On the offshore production installation
> a) every area that is likely to be regularly manned shall have at least two separate escape routes situated as far apart as practicable and leading to abandonment stations situated either on the helicopter deck, on the survival craft embarkation deck, at sea level, or at any combination of these locations,
> b) every such escape route and abandonment station shall be remotely accessible and unobstructed;
> c) means of escape leading to an upper level shall, wherever practicable, be provided in the form of ramps or stairways and means of escape leading to a lower level shall, wherever practicable, be provided in the form of ramps, stairways, or chutes;
> d) every boat landing shall incorporate nonslip surfaces and suitable guardrails;
> e) in addition to lifeboats and liferafts, there shall be suitable and sufficient means for persons to descend from the offshore production installation to the water in an emergency; and
> f) any appliance that is used for escape that does not form part of the production installation shall be stowed so as to be readily available and so designed and constructed as to be capable of withstanding the foreseeable environmental and operating conditions at the production site".

In general, the Board concludes that the requirements set out in the draft regulations are adequate insofar as lifeboats and liferafts are concerned and notes that the Proponent will be required to comply with the Regulations applicable to this subject. The Board also encourages the Proponent to continue the investigation of the dry evacuation system to which reference is made in the Development Plan.

3.7 Construction and Installation

In Chapter 7 of the Development Plan, the Proponent describes the construction of the Hibernia facilities in terms of scheduling, construction methods, work sites and installation procedures.

The schedule shown in Figure 3-18 illustrates the timing of the design, construction, and commissioning activities associated with the project. This schedule, which reflects the Proponent's thinking, has since been adjusted because of changes in the timing of certain "front-end" activities. However, the overall schedule remains as illustrated.

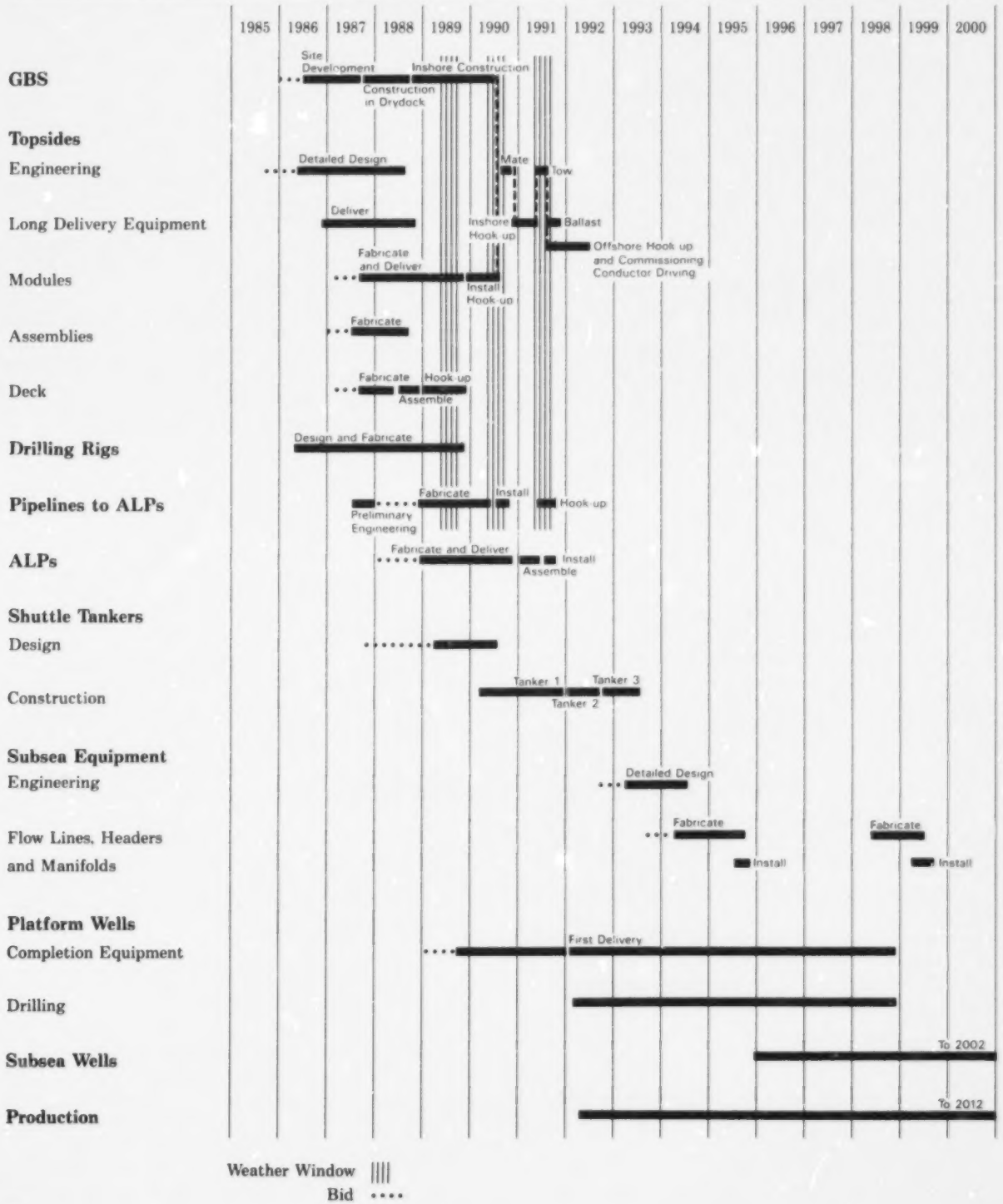
Design and construction of the subsea installations will be carried out over the period 1992 to 2002 in accordance with the requirements of the well development program discussed in Section 3.3, Reservoir Engineering.

The GBS caisson illustrated in Figure 3-19, will be constructed in the major phases illustrated in Figure 2-2.

This caisson will be made of high-quality, prestressed concrete reinforced by high-strength steel. The interior of the structure will be divided into a series of storage cells for solid ballast, water and oil. The enormous weight of the ballasted GBS will allow it to resist environmental forces, including sea ice and icebergs, and to maintain stability on the sea floor without pilings. Four hexagonal concrete shafts, extending approximately 30 metres above the caisson, will accommodate drilling and utility equipment and support the topsides facilities.

The topsides portion of the platform will be fabricated in sections in different fabrication yards and assembled as shown in Figure 2-3. The topsides structure will then be carried by barge to the deepwater construction site and "mated" or connected to the GBS which has been ballasted to allow this operation to take place. The GBS will then be refloated and the entire structure towed to the Hibernia site for final installation on the sea floor.

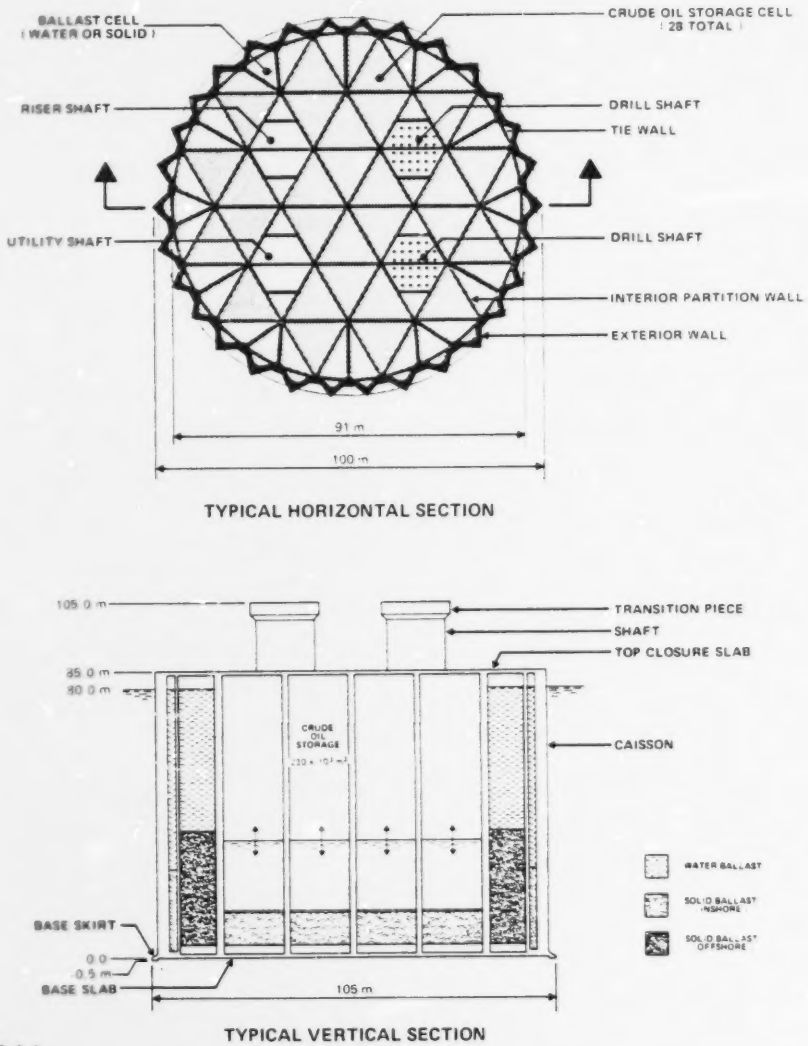
Figure 3-18
Tentative Development Schedule (after Proponent)



Oil from the production platform will be transferred from the storage cells in the GBS through subsea export lines to one of the two ALPs for tanker loading. Each ALP will consist of a base on the seafloor, to which a central buoyant column will be attached by a universal joint. A surface assembly on the central column will support facilities for tanker loading, mooring, and a helideck. The construction sequence for the ALP is illustrated in Figure 2-4.

The construction and installation process will be guided by an extensive series of regulations and inspections. The Certifying Authority will be required, before issuing a Certificate of Fitness, to survey the installation to ensure that it has been properly constructed in accordance with the approved design and is suitable for use at the intended location.

Figure 3-19
GBS Caisson Configuration



Source: HDP, Figure 6.2-1

3.8
Development Drilling, Completion, and Workover

In Chapter 8 of the Development Plan, the Proponent proposed the types of development wells and the drilling, completion and workover practices planned. These plans are described in more detail in Appendix D. As the field is developed and production experience gained, these practices and plans may have to be modified.

The Hibernia Project will involve simultaneous drilling and production activities. This combination is now routine in North Sea operations and the Proponent has stated that appropriate operating and safety procedures and comprehensive monitoring plans will be established to allow for contingencies.

For the Hibernia development wells, both water-base and oil-base drilling fluids are planned. It is intended that cuttings and fluids from a water-base mud system will be dumped directly into the sea and oil-base mud cuttings will be treated to compliance levels before being dumped.

The Board is generally satisfied with the Proponent's proposals and notes that all drilling, completion and workover practices will require an application for drilling plan approval. However, the treatment and disposal of effluents associated with development drilling require more particular attention.

3.8.1
Treatment and Disposal of Effluents Associated with Development Drilling

It is known that drill cuttings resulting from drilling with oil-base muds have a harmful effect on the marine environment; however the magnitude of this effect is not clearly understood. While the use of water-base muds is planned for the subsea wells at Hibernia, the Proponent has stated that a low toxicity, oil-base mud may be used below the 340 millimetre casing depth in an estimated 48 platform wells to be drilled into the Hibernia Sandstones. The oil-contaminated cuttings will be discharged overboard, after treatment to remove the oil to compliance levels.

The Proponent confirmed its intention to meet regulatory requirements for discharge concentrations and has stated that, if necessary, facilities will be installed to permit the washing of oil-base mud cuttings before dumping, and that oil-base wash discharge will be collected and treated. The Proponent has rated the expected impacts of oil-base mud cuttings as minor for benthic biota and negligible for fish and pelagic organisms (EIS, vol. IIIb, p. 28).

The Panel recommended that low toxicity drilling muds be used when oil-base muds are indicated during the project (Panel recommendation # 31). At the Panel hearings, Environment Canada also recommended this measure and added a requirement for treatment of cuttings before their discharge into the sea.

The Board notes that any use of oil-base mud will have to conform to the regulations and guidelines existing at the time of their use. The Board also notes that chemical additivies are periodically used to reformulate the mud, which may subsequently vary in composition and toxicity. Some additives may adhere to the cuttings resulting in variations in their potential toxicity as well. The use of such chemical additives currently requires prior regulatory approval.

The Board concludes that subsequent to treatment to compliance levels, it would be prudent to discharge oil-contaminated cuttings below the summer thermocline consistent with the recommended depth of discharge of many other effluents.

CONDITION 11

It is a condition of the approval of the Hibernia Development Plan that oil-contaminated cuttings be discharged below the summer thermocline.

3.9
Production Operations and Maintenance

In Chapter 9 of the Development Plan, the Proponent described its operations and maintenance guidelines for the development of Hibernia resources. The Proponent has indicated that a total of 990 people are expected to be directly involved with operations when production starts; of these, about 540 people will work on the platform. Additional personnel will be involved in operations related to drilling, maintenance and repair of subsea wells. A variety of training options will be available to develop job specific skills.

The Proponent stated that it would provide operations manuals which detail different operating procedures and which include a description of the various process, marine and safety systems. The Proponent also stated its intention to produce a loss prevention and control procedures manual that would describe a safety program involving joint safety committees of workers and management, requirements for employee training and guidelines for accident investigations and reporting. Contingency plans would be established to ensure proper responses should an emergency occur and exercises would be conducted to test their effectiveness.

The Proponent also stated its intention to establish monitoring and maintenance programs, including systems for monitoring the environment, production processes, safety and structural integrity. In addition, effects monitoring would be undertaken to detect changes in the environment surrounding the project area.

The Panel recommended that preventative measures be rigorously enforced by government and the Proponent during the life of the project in order to minimize damage to fishing gear by debris, (Panel recommendation # 34). The Board shares the Panel's concern on this issue and, although serious problems have not been experienced to date, the Board will take immediate and appropriate action should the need arise.

The Proponent described the logistics involved in development drilling and production operations including its intention to base such operations in St. John's. A dedicated multi-purpose support vessel was proposed. This vessel would be used for ice surveillance and clearing, evacuation, search and rescue, diving support, oil spill clean-up and fire fighting. It would also provide an on-scene communication and control centre that would supplement communication systems on the platform.

The Proponent acknowledged the need for a systematic reporting procedure, in the form of daily operations reports, monthly production and drilling summaries, environmental compliance monitoring reports, monthly safety reports and a quarterly training report. It also intends to maintain marine and aircraft logs and to establish a weather forecasting and ice management system in support of operations.

The Board is generally satisfied with the approach to operations and maintenance planning described in the Development Plan. The Board notes that, in addition, the Proponent will be required to conform with more detailed requirements contained in:

- Drilling Regulations,
- Production and Conservation Regulations,
- Production Installations Regulations,
- Diving Regulations, and
- Pipeline Regulations.

Notwithstanding the Board's general satisfaction with the Proponent's operation and maintenance philosophy, a number of aspects warrant further discussion. They are:

- Compliance and effects monitoring for discharges
- Structural and foundation integrity monitoring
- Ice management
- Contingency planning
- Weather forecasting
- Worker safety

3.9.1
Compliance and Effects Monitoring

While the Proponent has stated, in the Development Plan, its intention to institute compliance and effects monitoring programs, it did not provide details of these programs. Neither has government yet established specific guidelines for this purpose. Suitable monitoring programs must, therefore, be developed and implemented prior to the beginning of production.

Compliance monitoring is undertaken to ensure that contaminant discharge levels in effluents are within the limits set in regulations and guidelines. Effects monitoring is undertaken to detect changes directly or indirectly attributable to the project and to verify the Proponent's environmental impact predictions. The results of effects monitoring may indicate that modifications of operational procedures are required.

The Proponent also indicated that operating and maintenance procedures specific to the Hibernia facilities will evolve as the design and construction of the project are finalized. These procedures will be described in operations manuals containing details of both the environmental compliance monitoring and environmental effects monitoring programs.

The Proponent stated that the compliance monitoring program will ensure the processing of effluents to remove contaminants to the level required by regulations and guidelines and that effects monitoring will occur both during routine operations and in response to an oil spill or blowout. Monitoring of routine operations will concentrate on assessing the impact of produced water, storage displacement water and oil-base mud cuttings. The Proponent noted that potential contaminants from Hibernia include petroleum hydrocarbons and persistent and synthetic chemicals (biocides) and stated that its Hibernia effects monitoring program will concentrate on these chemicals (EIS, vol. IIIb, p. 124).

The Proponent stated that it supports generally, and will give serious consideration to, the monitoring strategies suggested in a recent Environmental Studies Revolving Fund (ESRF) study "Effects Monitoring Strategies and Programs for Canada's East Coast" (EIS Supplementary Information, p. 18) even though this study focuses primarily on the biological monitoring of the benthos. It was noted that effects monitoring techniques are still evolving and that the final program design will include the most recent monitoring technology. The Proponent further stated that its effects monitoring program instituted in response to a spill or blowout will include tracking the oil in order to notify fishermen and sampling to test for tainting of fish. The Proponent has indicated that monitoring programs will be developed in consultation with the appropriate regulatory and environmental agencies.

The Panel recommended that a monitoring plan should take into account the viewpoints of responsible government agencies and allow for publication of results (Panel recommendation # 40). At the Panel hearings, DFO stated that any effects monitoring scheme should be at least as comprehensive as those in place in the North Sea, address impacts from chronic and episodic events, focus on sublethal responses, use a suite of effects indicators and involve finfish as well as sessile organisms.

Environment Canada said that an effects monitoring program should be sensitive enough to measure increasing stress on the environment and that it should be capable of verifying impact predictions, detecting changes, evaluating the adequacy of regulated discharge requirements and defining corrective measures. Sublethal effects, as well as chronic and cumulative impacts, were cited by Environment Canada as being important parameters of such a scheme.

The Board believes that the details of both compliance and effects monitoring programs must be developed prior to the start of production. The Proponent's statements on compliance monitoring are acceptable to the Board. The discussion of effects monitoring options (EIS vol. IIIb, p. 120-125; Supplementary Information, p. 17) indicated the Proponent's appreciation of the complexity of the issue and of the evolution of monitoring techniques. The decision to focus on assessing the impacts of produced water, storage displacement water and oil-base mud cuttings and to concentrate on monitoring petroleum hydrocarbons and persistent and synthetic chemicals appears to be appropriate.

The Proponent's effects monitoring program should be developed taking into consideration the recommendations of appropriate government agencies made at the Panel hearings. The Board intends to request the advice of other government agencies during the development with the Proponent of the requirements of an acceptable effects monitoring program. The responsibility for developing the program to meet government requirements resides with the Proponent.

CONDITION 12

It is a condition of the approval of the Hibernia Development Plan that prior to production, the Proponent submit, for the Board's approval, its plans for environmental compliance and effects monitoring programs.

3.9.2
Structural and Foundation Integrity Monitoring

The Hibernia GBS will likely be the first production platform to be installed in the Northwest Atlantic. Differences in seabed, in environmental and loading conditions and in operational requirements are such that estimation of the GBS behaviour is not a simple extrapolation of available data from platforms in other areas. The Hibernia platform will be subjected to severe loads during construction and installation and by the environment. It is necessary to verify the validity of the design assumptions and to monitor the safety of the structure by providing adequate instrumentation for that purpose.

The Proponent has indicated that the structure would be monitored throughout its operational life as part of the regular maintenance programs. Platform inclination, settlement, displacement and foundation soil pressure would be monitored. In addition, instrumentation would be installed to ascertain load distribution measurements during installation of topside facilities and stress levels arising in the structure from storms and sea ice loading (EIS, V. II, 10.1.4 and 10.2).

The Board recognizes that gravity based concrete platforms have been successfully used in the North Sea. However, the Hibernia GBS introduces a number of new features, including a unique design to withstand iceberg impact and a large caisson piercing the sea surface.

These innovations require new analytical techniques or the extension of existing ones. The need to verify the validity of the design assumptions by full scale observations is, therefore, obvious. Also, instrumentation is required when visual inspection or simple measurements are not practicable or sufficiently reliable to predict the performance of the structure and its foundation. Detailed regulatory requirements have not yet been established for the level of instrumentation to be installed. The Board will ensure that the Certifying Authority conducts a review of the design to ascertain the areas when instrumentation will be required.

CONDITION 13

It is a condition of the approval of the Hibernia Development Plan that the Proponent provide instrumentation for structural and foundation integrity monitoring and that the extent of such instrumentation be determined in consultation with the Certifying Authority and approved by the Board.

3.9.3
Ice Management

The Proponent has stated its intention to provide a comprehensive ice management program during production at Hibernia. This program is expected to reduce the estimated number of impacts with the GBS from icebergs of any size by one half, that is, from one impact every fifteen years to one every thirty years.

Ice management is intended to be based on the methods and practices developed during exploration on the Grand Banks. The proposed ice management program will identify a series of alert zones surrounding the field facilities. These zones will be based on ice speed and time required to shut-in operations. Response to ice in these zones will range from routine surveillance or attempting control of iceberg movement, to discontinuing a particular operation or departure of vessels from their field locations. The Proponent stated that if it appears such ice will pose a threat to production operations, an Alert Response Team will carefully evaluate all options and identify the resources needed to prevent an emergency situation from occurring.

It was proposed that the production platform and all associated marine vessels would be fitted with state-of-the-art ice detection systems, that research and development into ice detection sensors, iceberg towing and ice forecasting would continue to be supported and that any new resulting technology will be incorporated into the ice management system for production. Environment Canada and DFO noted that under conditions of poor visibility and high sea states, bergy bits, growlers and ice floes are not detectable with high confidence using present day remote sensing techniques. Environment Canada also recommended that the Proponent should provide details on the operation of a real-time ice forecasting system.

The Panel recommended that an effective ice management system should be an integral component of the project and that research and development to improve the ability to detect and manage ice under adverse weather conditions be undertaken (Panel recommendation # 24).

The Board accepts the Panel's recommendation, agrees with the Proponent's proposed approach to ice management and notes that an ice management plan acceptable to the Board will be required under the Production and Conservation Regulations prior to the start of production. The Board is satisfied with the research and development efforts conducted by the Proponent and through the Environmental Studies Revolving Fund.

3.9.4
Contingency Planning

The Proponent has emphasized in the Development Plan that proper preplanning and emergency preparedness are essential to control emergency situations quickly and to minimize the severity of impacts on life, property, and the environment. A documented offshore alert-emergency response plan will provide a system for quick communication of the essential details of an emergency or impending emergency to those people who need to react immediately, in order to ensure that the correct response is taken to mitigate the threat. The plan will also identify actions required for those situations when there is not sufficient lead time to declare an alert phase.

The Proponent has recognized that several government agencies are involved with the petroleum industry in providing a response capability for offshore emergencies and has referred to the existing Grand Banks Multi-Operator Alert Response Plan to illustrate its approach.

With regard to oil spill emergencies, the Proponent stated that the response program in place for exploratory drilling operations will form the basis for an oil spill response capability during production. According to the Proponent, the East Coast Spill Response Association (ESRA), or its equivalent, will form the first line of response in the event of an oil spill and additional resources, drawn from the Proponent's worldwide organization, will be available as need dictates.

At the Panel hearings, Environment Canada stated that the Proponent had not adequately addressed the risk of a major oil spill. The Panel concluded that there was a significant chance of a blow-out during the life of the project but that there was an even greater likelihood of batch spills during storage or transfer, because of the difficult climatic conditions of the site.

The Panel further concluded that the tanker transport of Hibernia oil would create increased traffic in environmentally sensitive areas and that, even with the special double-hulled and ice strengthened tankers to be built for the project, (Panel recommendation # 28) the risk of an oil spill might be increased above that which now exists. The Panel recommended that a mechanism be established through consultation with resource managers and shipping authorities for the safe routing of tankers to and from the Hibernia site. (Panel recommendation # 29).

The Panel also recommended that in view of the limited capability for offshore cleanup, special emphasis be placed on prevention of offshore spills; that contingency plans take into account both inshore and offshore impacts; that research to develop effective countermeasures be accelerated by industry and government, and that measures be taken to minimize oil spills from ALPs and subsea components due to iceberg impact (Panel recommendations # 22, # 23 and # 30).

The Board supports the Panel's recommendations and accepts the Proponent's commitment to develop suitable contingency plans which will include a set of criteria to establish when ice and weather events will cause tankers to be disconnected and the ALPs and subsea components to be shut in and flushed, thus minimizing the risk of oil spillage.

Although no legislative authority exists to enable the Board to designate tanker routing offshore, the Board will ensure that the oil spill contingency plans which will be required under the Production and Conservation Regulations identify biologically sensitive areas. The Board will also request the Proponent to require its shuttle tanker captains to avoid such areas whenever possible.

The Board is satisfied with the current level of research and development conducted by both industry and government in the field of oil spill countermeasures.

The Board, therefore, concludes that the Proponent's approach to contingency planning is acceptable, and notes that detailed contingency plans will require the approval of the Board prior to the commencement of operations.

3.9.5
Weather Forecasting

During the Panel hearings, Environment Canada stated that the safe operation of a production platform, supply ships, helicopters and tankers requires a dedicated staff of knowledgeable forecasters and technicians.

The Panel recognized that complete and timely information on weather conditions would be important to the safe operation of the project and recommended that a dedicated weather forecasting system be incorporated as an integral part of the project (Panel recommendation # 27).

The Proponent has stated that

> "Weather conditions recorded by observers on the platform will be combined with weather information available from the public domain to generate site-specific marine weather forecasts. These forecasts, along with forecasts generated by the Atmospheric Environment Service (AES), will aid in planning operations at the site as well as along the tanker routes. . . . Forecasts will normally be issued up to four times daily. During sensitive operations or periods of potentially severe weather, forecasts may be issued more frequently. . . . These weather forecasts will be used to plan field operations such as the scheduling of shuttle tankers".
>
> (HDP, Section 9.5.2).

The Proponent also stated that aviation weather forecasts will be provided by AES and will be issued on a site-specific basis every 6 hours for St. John's and alternative airports and twice daily for the platform.

The Board accepts the Panel's recommendation and believes that the Proponent's stated intention to provide site-specific weather forecasts meets the requirement for a dedicated weather forecasting system. The Board also notes that a weather forecasting system acceptable to the Board is required in the Conservation and Production Regulations.

The Board concludes that the Proponent's approach to weather forecasting is acceptable.

3.9.6
Worker Safety

The safety of workers engaged in offshore activities is an area of critical concern to the industry, the regulatory authorities and the population at large. The Royal Commission on the *Ocean Ranger* Marine Disaster has made a number of recommendations in this regard and the subject attracted considerable attention during the public hearings held by the Panel.

The Panel recommended that measures for prevention of accidents and prompt medical treatment of workers both onshore and offshore be considered an integral part of the project planning. (Panel recommendation # 42).

The Proponent has stated that the production system will include many features for personnel safety, including:

- "Remote controls to avoid manual operations in the vicinity of moving equipment
- Emergency escape routes from enclosed areas
- Inert gas blanket on cargo tanks to keep combustible gas concentrations below the explosive range
- Flashback protection on flare systems
- At least two separately located fire muster stations on each platform equipped with protective equipment and breathing apparatus
- Muster stations located for abandonment
- Marine safety equipment such as covered lifeboats, davit-launched liferafts, survival suits, life jackets, search beacons, emergency handset radios, life buoys, foghorns and navigation lights
- Fire walls around control rooms, living quarters and emergency equipment
- Structural barriers over platform wellheads to divert dropped objects
- Equipment for degassing and skimming hydrocarbon liquids from closed drains
- Modern data and communications equipment, including radar, doppler speed log, VHF radio telephone, approach track sonar, sound-powered and automatic telephones, loudspeaker system and telemetry equipment
- Trained medic in the field at all times, supported by a well-equipped sick bay
- Standby ships equipped with rescue equipment
- Helicopters equipped with rescue equipment."

(EIS Volume II, 4.1.3.6)

The Board has stated in its introduction to this section that worker safety is an area of critical concern. The stated intentions of the Proponent indicate that worker safety is an integral part of the design of the facility and the safety systems. The specific requirements to meet many of the above objectives are set out in the regulations and guidance notes. It is the Board's intention to ensure that these requirements are met and to instruct the Certifying Authority to examine carefully the designs proposed by the Proponent from a worker safety perspective. The Board's approval at this time must, therefore, be limited to an endorsement of the conceptual approach described by the Proponent.

The Panel recommended that measures be taken to ensure that it is clear which regulatory regime applies during the different phases of the construction and operation of the project and that workers are aware and encouraged to use procedures for reporting poor safety conditions. (Panel recommendation # 43).

The Board notes that the legislation introduced to implement the Atlantic Accord provides that Newfoundland social legislation, including the *Labor Standards Act, the Occupational Health and Safety Act* and the *Workers' Compensation Act*, will apply to facilities or structures installed in the offshore area. The implementing legislation also specifies that drilling operations and equipment are exempted from the general application of these statutes and are to be governed by regulations specific to the purpose.

The Board further notes that construction at inshore sites will be subject to provincial legislation and that workers on supply boats and tankers will be covered by federal legislation.

The Board, therefore, concludes that the regulatory regime applicable to the various phases of the project has been clearly established and is satisfied that the legislation in place, in each case, provides for procedures for dealing with unsafe conditions.

CONDITION 14

It is a condition of the approval of the Hibernia Development Plan that prior to installation of the facilities, the Proponent obtain the Board's approval of detailed plans for worker safety.

3.10
Development Costs

The Proponent has included in the Hibernia Development Plan estimates of the capital cost of the project, in both 1984 and "as spent" Canadian dollars. These estimates were provided for major project components and for the project as a whole.

The estimates appearing in the Development Plan are consistent with those presented by the Proponent in the Hibernia Environmental Impact Statement, taking into account the evolution in the definition of the project concept which ocurred during the period between the submission of the two documents.

The Board recognizes that the cost estimates for the project and its various components will continue to be revised as designs are refined, bids received and work on the project progresses.

The Board does not believe it necessary to verify or otherwise approve the Proponent's estimates; they are considered adequate for the Board's purposes at this time. The Board notes that it needs current cost estimates to perform properly its monitoring function.

CONDITION 15

It is a condition of the approval of the Hibernia Development Plan that the Proponent provide periodically to the Board, during the execution of the project, in a form to be prescribed, estimates of the expected capital cost for the project as a whole and for those major components which the Board shall request.

3.11
Environmental Protection Issues

The Board has broad responsibility to ensure that the facilities it approves for installation are designed and operated in an environmentally acceptable manner. The Board has taken a cautious approach in dealing with environmental issues because the Hibernia Field is located in an area which contains a fishery resource upon which the people and economy of Newfoundland are heavily dependent.

In its Environmental Impact Statement (EIS), the Proponent addressed most environmental protection issues. In many instances, its statements were limited to commitments to comply with applicable legislation, to develop monitoring and contingency plans or to negotiate compensation arrangements with affected parties. Intervenors at the Panel hearings stated opinions as to deficiencies in the EIS and expressed concerns about a variety of environmental issues. The Panel considered these matters in formulating its recommendations (Appendix A).

The Development Plan was written and presented to government before the Panel Report was completed and, as such, was not influenced by the Panel's recommendations.

Although the Development Plan did not describe the measures contemplated for environmental protection in great detail, this approach was acceptable to the Board because accurate information will become available only as the Proponent proceeds with its detailed design. The Board believes that the preparation of contingency plans and monitoring programs will also be carried out more efficiently as the detailed project design evolves. The Board, therefore, approached environmental protection issues from the perspective of ensuring the required detailed information is provided as it becomes available.

The Board has identified a number of environmental protection issues associated with the Hibernia development. Where the issues were addressed in the Development Plan, the Board has discussed requirements in the corresponding sections of this report. (Sections 3.4, 3.6, 3.8 and 3.9).

Three areas of concern not addressed in the Development Plan but considered by the Board to require action, are:

- Fisheries exclusion issues
- Fisheries compensation
- Environmental protection plan.

3.11.1
Fisheries Exclusion Issues

The Proponent has proposed that an exclusion zone of approximately 8 km x 13 km, corresponding to the location of production facilities on the sea surface and on the seabed, be established for the Hibernia development. The Proponent believes that the effective exclusion area may increase to 18 km x 23 km because many skippers will voluntarily maintain an additional distance from the development field (EIS, vol. IV, p. 249). At the Panel hearings, the Proponent predicted that an exclusion zone of this size would have a negligible impact on the overall fishery. The Board has been advised that the Proponent has continued to participate in discussions with the fishing industry regarding loss of access to fishing areas since the conclusion of the hearings.

During the Panel hearings, fisheries interests questioned the accuracy of the Proponent's catch statistics and the feasibility of displacing fishing effort. They were also concerned that a precedent might be set by the creation of the exclusion area around the Hibernia development.

The Panel report recommended a further examination of the 8 km x 13 km exclusion area by the Board in consultation with the fishing industry (Panel Recommendation # 33).

The Board concludes that an exclusion zone is necessary around the Hibernia development area and this zone must be large enough to protect the production facilities units and subsea installations.

CONDITION 16

It is a condition of the approval of the Hibernia Development Plan that prior to production, the Board will establish the dimensions of a fishing exclusion zone following consultation with the Department of Fisheries and Oceans, the fishing industry and the Proponent.

3.11.2
Fisheries Compensation

During the Panel hearings, the issue of a comprehensive program to provide compensation to fisheries interests for losses arising from offshore petroleum activity in general, and the Hibernia development in particular, arose. Operators are individually responsible for losses directly attributable to their actions (e.g. spills or debris) and have jointly established, though the Canadian Petroleum Association and in consultation with fisheries interests, a system acceptable to both for non-attributable damage to boats and fishery gear. However, no protection is expressly provided for plant owners and workers who may experience loss of income as a result of an oil spill or, in the case of offshore trawler operations, as a result of being denied access to traditional fishing grounds.

The related issue of losses by inshore fishermen whose activity is displaced or reduced during the construction phase also arose during the Panel hearings.

At the hearings, the Proponent submitted that there has been no provision either in Scotland or in Norway for compensation to the fishing industry for loss of access to fishing grounds. However, it stated it was willing to consider compensating inshore fisherman for lost fishing time or lost fishing opportunity if it could not arrange mutual avoidance (Panel report, p. 37). The Proponent has indicated that compensation for loss of access is under discussion at ongoing meetings between the two industries. The Proponent also stated it was willing to consider compensation to the processing sector where there was demonstrated economic loss (Panel report, p. 38).

In its intervention, DFO urged the Panel to consider the role that compensation could play in resolving future pre-emption of fishing from exclusion zones. DFO also stated that the potential impact on the processing sector had not been adequately addressed.

The Panel has recommended that government establish a comprehensive policy of compensation for all types of potential economic damage to fisheries interests including induced effects on the processing sector and loss of access to fishing grounds, (Panel recommendation # 35).

The Board is responsible for requiring provision for financial responsibility for attributable damage and promoting and monitoring compensation policies for non-attributable damages.

The Board believes that the best compensation program for damages to fisheries interests resulting from offshore petroleum activities would be one which is developed by the parties involved and which includes a procedure for the settlement of disputes between them.

The Board notes the statements of the Proponent regarding the discussions which are taking place with fisheries interests in the area where construction activities are expected, and urges the parties to reach agreements satisfactory to both, prior to the start of construction.

The Board also urges discussion between the Proponent and representatives of those fishing interests potentially affected by an environmental accident arising from the Hibernia development to establish, in advance of the installation of facilities, a program to provide compensation for those economic losses which might consequentially occur.

The Board is prepared to arrange for such expert advice as may be necessary to achieve these purposes and, in the absence of agreement between the parties, to use its authority to impose the establishment of such a program.

3.11.3
Environmental Protection Plan

It is a policy of government and a fundamental expectation of the public that development occurs in an environmentally responsible manner.

The Board has been charged with overall responsibility for ensuring that petroleum-related activity in the Newfoundland offshore area is conducted in an environmentally sound manner. However, certain departments of both federal and provincial governments also have related statutory responsibilities or valid interests concerning the environment.

It is necessary, therefore, that information now distributed throughout the Development Plan describing the Proponent's intentions on environmental issues, be accessible to those who have legitimate responsibilities in this regard.

Both DFO and Environment Canada stressed to the Panel the need for a broadly based Environmental Protection Plan (EPP) and the importance of making the EPP available to them.

The Newfoundland Department of Environment has initiated a process based on the preparation of an Environmental Protection Plan for the land-based construction activity associated with the Hibernia development.

The Board notes that while the Proponent did not make provision for the preparation of an EPP in its Development Plan, it did state in its EIS Supplementary Information document that an Environmental Protection Plan would be developed for all phases of the project.

The Board has concluded that it is desirable for the Proponent to produce such an EPP and that it should bring together, in one document, a description of the environmental protection measures and programs which are proposed for the project. The EPP should be produced in a form which can be progressively updated as details are defined during the evolution of the design or as procedures for environmental management are confirmed.

Recognizing that changes, additions or deletions may be required during project development, the Board would expect the EPP to contain descriptions of the following.

- waste treatment equipment and effluent disposal plans;
- drilling mud programs and associated waste treatment equipment and effluent disposal plans;
- produced water treatment equipment and effluent disposal plans;
- methods to control biofouling of the facilities;
- type, rate and amount of pipeline flushing solutions to be used and effluent disposal plans;
- protective and mitigative measures for activities related to transportation and offloading of environmentally hazardous supplies;
- plans for environmental restoration at abandonment;
- compliance and effects monitoring programs;
- weather and seastate forecasting and observation programs;
- contingency plans for alert/emergency situations; and
- agreements with the fishing industry concerning mitigative measures and compensation schemes to deal with potential negative impacts.

CONDITION 17

It is a condition of the approval of the Hibernia Development Plan that the Proponent, prior to production, submit to the Board for approval, an Environmental Protection Plan describing its systems, procedures, plans and agreements for environmental protection.

4.0
The Board's Decisions

Benefits Plan Decision

It is the decision of the Board that the Hibernia Benefits Plan is approved, subject to the following conditions:

CONDITION 1
That the Proponent consider all reasonable alternatives to provide for maximum Canadian participation in shuttle tanker construction, and inform the Board of the results of these investigations.

CONDITION 2
That, prior to the start of production, the Proponent submit a training and staffing plan reflecting the maximum reasonable employment and training of residents of Newfoundland.

CONDITION 3
That the Proponent re-examine the feasibility of assembling and outfitting the main support frame in Newfoundland and provide further documentation to enable the Board to evalute the matter.

CONDITION 4
That as the project evolves, the Proponent provide to the Board comprehensive listings of all major contracts and purchase orders anticipated. The Board, in consultation with the Proponent, will determine which of these major contracts and purchase orders will be subject to Board review.

CONDITION 5
That the Proponent provide advance notice of and information on major contracts and purchase orders to enable the Board to conduct its review. The review time required will be determined by the Board, in full consultation with the Proponent.

Development Plan Decision

It is the decision of the Board that the Hibernia Development Plan is approved, subject to the following conditions:

CONDITION 1

(i) That the Proponent at a very early stage in the development program, drill a well in the area of the B-08 gas cap, to obtain gas cap samples for laboratory analyses and define a gas-condensate-oil regime; and

(ii) that the Proponent undertake studies, concurrent with initial development drilling, to establish the feasibility of a miscible flood for the Hibernia Reservoir.

CONDITION 2

(i) That prior to any development of the Avalon Reservoir, the Proponent submit a revised plan for the Board's approval;

(ii) that during development of the Hibernia Reservoir, the Proponent evaluate the Avalon Reservoir by coring, logging and testing all prospective zones penetrated by wells drilled to the Hibernia Reservoir; and

(iii) that during the design of topside facilities, the Proponent give due consideration to sizing equipment and allocating space for production facilities and utilities, sufficient to accommodate additional production from the Avalon Reservoir concurrently with Hibernia production, should there be a requirement to produce the Avalon Reservoir prior to the time contemplated in the Development Plan, and that the Proponent report to the Board on its actions in this regard before the topside facilities design is finalized.

CONDITION 3

(i) That the Proponent file for approval by the Board, prior to commencement of development drilling, a specific drilling schedule designed to reduce gas flaring to limits acceptable to the Board;

(ii) that in the unlikely event that reservoir conditions prevent gas re-injection, the Proponent present to the Board for approval a plan for gas disposal; and

(iii) that the Proponent obtain the Board's approval to flare those small volumes gas needed for normal operations.

CONDITION 4

That the Proponent conduct a study on the estimation of extreme winds caused by mesoscale events and submit the results of the study to the Board prior to using them for design purposes.

CONDITION 5

(i) That the Proponent design the export lines and loading platforms so that they can be flushed of hydrocarbons if there is risk of damage to those facilities; and

(ii) that the design iceberg scour depth be determined by the Proponent and approved by the Board prior to the design of subsea well installations.

CONDITION 6

That the Proponent re-evaluate the seismic design criteria, taking into account the recent and ongoing studies related to seismic risk on the eastern Canadian Continental Shelf, and submit the results of this re-evaluation to the Board for approval prior to using the results of the study for design purposes.

CONDITION 7

(i) That produced water which is to be discharged be treated to comply with the regulatory requirements existing at the time; and

(ii) that before finalizing the design of facilities the Proponent submit for the Board's approval a plan for the re-injection of produced water in the event that the effects monitoring program should disclose unacceptable environmental damage resulting from that source.

CONDITION 8

(i) That the Proponent allow in its design for the facilities to treat storage displacement water should treatment become necessary; and

(ii) that the Proponent design its facilities so that fluid discharges will occur below the summer thermocline.

CONDITION 9

That the Proponent obtain specific approval from the Board for its plans for subsea installations prior to proceeding with the detailed design of these facilities.

CONDITION 10

That the Proponent design all subsea facilities such that, upon termination of production, they will be capable of being covered or removed so that the area is returned to a fishable condition, and design the GBS so that it could be removed if the Authorities at that time so require.

CONDITION 11

That oil-contaminated cuttings be discharged below the summer thermocline.

CONDITION 12

That prior to production, the Proponent submit, for the Board's approval, its plans for environmental compliance and effects monitoring programs.

CONDITION 13

That the Proponent provide instrumentation for structural and foundation integrity monitoring and the extent of such instrumentation be determined in consultation with the Certifying Authority and approved by the Board.

CONDITION 14

That prior to the installation of the facilities, the Proponent obtain the Board's approval of detailed plans for worker safety.

CONDITION 15

That the Proponent provide periodically to the Board, during the execution of the project, in a form to be prescribed, estimates of the expected capital cost for the project as a whole and for those major components which the Board shall request.

CONDITION 16

That prior to production, the Board will establish the dimensions of a fishing exclusion zone following consultation with the Department of Fisheries and Oceans, the fishing industry and the Proponent.

CONDITION 17

That the Proponent, prior to production, submit to the Board for approval, an Environmental Protecton Plan describing its systems, procedures, plans and agreements for environmental protection.

Appendix A

Recommendations of the Hibernia Environmental Assessment Panel

December, 1985

Recommendations of the Hibernia Environmental Assessment Panel
December, 1985

The Panel recommends that:

1. government should establish, and the Proponent be required to meet, realistic goals for Newfoundland employment on the project. Emphasis should be placed on long-term jobs in the production phase and jobs developing skills transferable to future projects;

2. the Proponent should regularly provide to government a detailed list of projected job opportunities as the planning of the project evolves;

3. a policy on local hiring should be adopted by the government prior to construction. A local hiring office should be established for the benefit of local residents. Hiring for workers outside the local area should occur at centres elsewhere in the province;

4. any requirement for union membership should not give non-residents preference over qualified Newfoundlanders wishing to work on the project;

5. a comprehensive training strategy, including both institutional and on-site components, should be developed for this project and concentrate on areas of greatest long-term benefit;

6. government should take into account the possibility of limited labour force displacement from fisheries and shipbuilding in its training strategy for the project;

7. opportunities for increased employment of women offshore should be addressed through overall government policy and project-specific employment requirements;

8. a plan establishing targets for Canada and Newfoundland industrial benefits should be agreed upon by governments and the Proponent prior to project commencement and should be closely monitored throughout its life. Critical elements which should be included are the timing and size of contracts, technology transfer, application to subcontractors and the need of on-going consultation to ensure awareness of project opportunities;

9. the Proponent should continue discussions with Marystown to establish the extent and nature of the town's participation in the project and ensure orderly development;

10. appropriate training and assistance to small businesses should be provided to maximize benefits from the induced and indirect effects of the project;

11. timely informaiton on expected population influxes should be provided continuously by the Proponent and its contractors to appropriate authorities to allow them to provide necessary services;

12. special measures should be taken to increase the supply of rental housing in St. John's with particular emphasis on providing more units for low or fixed income groups. Existing programs should be expanded by use of the Offshore Development Fund.

13. government should monitor the demand for owner-occupied housing in St. John's to ensure that sufficient lots are available to meet the demand and avoid unnecessary inflation;

14. planning should begin on the provision of additional facilities for transients in the St. John's area;

15. discussions should occur between the Proponent and local governments in the Come By Chance and Argentia areas concerning the numbers and types of temporary family housing units that will be required;

16. full consultation should take place prior to development to identify necessary improvements to impact area infrastructures. Both the Proponent and government agencies should involve local representative in discussions on requirements.

17. appropriate authorities should institute adequate controls and, if necessary, provide incentives from the Offshore Development Fund, to encourage preservation and restoration of areas of architectural heritage in St. John's;

18. the Offshore Development Fund should be used to provide adequate social services in areas affected by the development. Funding should be provided prior to, during and after the life of the project;

19. community impact agreements should be developed for areas directly affected by the project. These should address housing, infrastructure and social service requirements. Such agreements would provide a written understanding of the division of responsibilities among senior levels of government, the Proponent and local authorities. They would also establish the basis for funding monitoring and data collection and provide for arbitration of disputes that may arise during the project;

20. work camp location and access should be discussed with local communities prior to site work commencing;

21. work camps should provide recreation facilities, medical and counselling services and other requirements determined following consultation with the workforce and local communities;

22. the ALPs should be designed to ensure that oil spills are avoided in the event of failure of system components or the structure itself;

23. complete protection of subsea components, by measures such as burial, should be considered for protection against iceberg impact;

24. an effective ice management system should be an integral component of the project. Research and development to improve the ability to detect and manage ice under adverse weather conditions should be undertaken;

25. the structure should be built to ensure human safety and structural integrity from wave forces. In particular, the topsides and supporting structures should be conservatively designed to allow for the possibility of episodic waves;

26. the results of ongoing studies on seismicity, seabed stability and possible subsidence should be incorporated into the design of the GBS and other offshore components;

27. a dedicated weather forecasting system should be incorporated as an integral part of the project;

28. the design of tankers should incorporate all necessary features for Hibernia conditions including double hulls and ice-strengthening;

29. a mechanism should be established to ensure the safe routing of tankers in shipping oil from the Hibernia site. This must take into account the safety of the tanker and the environmental sensitivity of the area traversed, and should be done through consultation with resource managers and shipping authorities;

30. in view of the limited capability for offshore cleanup, special emphasis should be placed on prevention of offshore spills. Contingency plans should take into account both inshore and offshore impacts. In addition, research to develop effective countermeasures should be accelerated by the industry and government;

31. mitigative measures such as reinjection of produced water, treatment and discharge of storage water below the summer thermoclime, and the use of low toxicity drilling muds should be implemented during the project;

32. DFO should develop a contingency plan for the administration of selected temporary fishery closures in the event of an oil spill. Accurate tracking of the spill together with consultation with the fishing industry will be required;

33. further examination should be undertaken of the 8 km x 13 km exclusion area by the Canada-Newfoundland Offshore Petroleum Board in consultation with the fishing industry;

34. preventative measures should be rigorously enforced by government and the Proponent during the life of the project in order to minimize damage to fishing gear by debris;

35. the government should establish a comprehensive policy of compensation for various types of potential economic damage to fisheries interests, prior to project commencement. This should establish simple standardized procedures for all types of economic damage including matters such as induced effects on the processing sector and loss of access of fishing grounds;

36. the government should maintain the Vessel Traffic Services facility at Argentia throughout the construction phase of the project and the petroleum industry should consult with fisheries interests on the establishment of vessel traffic lanes in Placentia Bay and offshore;

37. examination of potential sources of aggregate for GBS construction should take into account possible environmental effects and any quarry operation should include appropriate environmental protection measures;

38. the entire development area should be restored to a fishable condition upon abandonment of the project;

39. the GBS should be designed in such a way that it could be refloated and removed if necessary;

40. a monitoring plan should be developed taking into account the viewpoints of the responsible government agencies and allowing for publication of results. The government agencies should consult with interested public groups concerning the monitoring program;

41. functional project evacuation systems should be provided prior to production commencement;

42. measures for prevention of accidents and prompt medical treatment of workers both onshore and offshore should be an integral part of the project planning;

43. measures should be taken to ensure that it is clear which regulatory regime applies during the different phases of the construction and operation of the project and that workers are aware and encouraged to use procedures for reporting poor safety conditions.

The Panel further recommends that:

44. governments should consider establishing terms of reference of future panels which would permit a more comprehensive review of further offshore developments, including aspects falling within the jurisdictions of the governments;

45. a one-year time frame (not including any time required to obtain any new information from the Proponents) should be allowed for the review of projects of this magnitude and importance;

46. intervenor funding should be provided for future offshore projects but that an impartial committee should establish criteria for funding eligibility and decide on its allocation;

47. research under the Environmental Studies Revolving Fund should be carried out to assist government in examining strategic issues for area-wide planning of offshore development;

48. the Offshore Petroleum Board should establish suitable mechanisms to ensure a continuing exchange of views between itself, government agencies, the Proponent and the public during the life of the project;

49. the Offshore Petroleum Board should consider means by which agencies having related mandates are permitted to examine relevant technical data and design criteria;

50. government should develop an overall strategy for implementation of these recommendations with appropriate funding levels and sources, such as the Offshore Development Fund.

Appendix B Glossary

Abandonment suit
Protective clothing providing varying degrees of insulation from cold air or water.

AES
Atmospheric Environment Service.

ALP
Articulated Loading Platform used to load oil into tankers offshore.

Anticline
A fold in rock strata which dip in opposite directions from a common axis.

Anti-corrosive
Anything which serves to prevent corrosion or to offset its effects.

Aquifer
A porous rock that is water bearing.

Arenite
Consolidated rock with the texture of sand.

Argillaceous
Sediments made of clay or of very fine-sized particles.

Benthos
Organisms living on or in the bottom sediments, as opposed to, for example, fish which live in the water column.

Bergy bit
Small fragment of iceberg. Usually considered to weigh from 200 to 700 tonnes, to be 1 to 5 metres high and to be 6 to 20 metres long. Bigger than a growler.

Biocide
Any substance which destroys life; usually with reference to micro-organisms.

Biofouling
The undesirable growth of living organisms on or in man-made structures.

Biota
A general, collective term for assemblages of living organisms of all types.

Board, the
In this report only, the Canada-Newfoundland Offshore Petroleum Board.

Caisson
A structure composed of one or more watertight chambers or cells, for use under water.

Calcareous
Made of, or containing, calcium carbonate.

Carbonates
Sedimentary rocks consisting mainly of calcium or magnesium carbonate.

Carbonate cementation
The cementing together of rock grains by filling interstitial spaces with carbonate compounds.

CEIC
Canada Employment and Immigration Commission.

Cellar deck
The lowermost deck on the MSF on which the topside modules are placed.

Cenozoic
The latest of the four eras into which geologic time is divided; from 65 million years ago to historic times.

Certifying Authorities
Bodies licenced by the Board to conduct examination of designs, plans and facilities and to issue Certificates of Fitness.

Certificate of Fitness
A certificate issued by a certifying authority stating that a design, plan or facility complies with the relevant regulations or requirements.

Clastic
Rocks composed of broken fragments of older rocks.

COGA
Canada Oil and Gas Act.

COGLA
Canada Oil and Gas Lands Administration.

Completion
The activities necessary to prepare a well for the production of oil and gas.

CPR
Canadian Participation Rate

Cretaceous
The third and latest of the periods included in the Mesozoic era. From 140 to 65 million years ago.

Cuttings
Chips and small fragments of rock that are brought to the surface by the drilling mud as it circulates.

Delineation well
Well drilled to determine the extent of a reservoir.

DFO
Federal Department of Fisheries and Oceans.

Diagenesis
The chemical and physical changes that sediments undergo during and after their accumulation.

Directional drilling
Intentional deviation of a wellbore from the vertical to reach target areas laterally displaced from the point where the drill bit enters the earth.

DRIE
Department of Regional and Industrial Expansion.

Drilling fluid
Special fluids, either oil or water based, used to cool and lubricate the drill pipe and drill bit.

Drilling mud
A special mixture of clay, water and chemical additives pumped down the wellbore through the drill pipe and drill bit to cool the rotating bit, lubricate the drill pipe as it turns the rotating bit in the wellbore, carry rock cuttings to the surface, and control downhole pressure. Water base or oil base drilling mud may be used.

Drill string
The column of drill pipe.

Drill water
Water used as the liquid phase in water base mud; usually denoting nonsaline water.

Dry dock
A dock that can be kept dry for use during the construction or repair of ships.

DST
Drill stem test. A short test of the productive capacity of a well through drill pipe.

DWT
Deadweight tonnage; the maximum design weight of cargo, crew and effects for a ship.

EA
Exploration Agreement.

Effluents
The liquid waste discharges of sewage and industrial processing.

EIS
Environmental Impact Statement (or Study); in this report, the EIS prepared by Mobil for Hibernia.

EMR
Federal Department of Energy, Mines and Resources.

Enriched gas injection
A secondary recovery method for injecting gas which is either naturally rich in or is enriched with intermediate hydrocarbons such as propane, butane.

Episodic
Occurring irregularly.

EPP
Environmental Protection Plan.

ESRA
East Coast Spill Response Association.

ESRF
Environmental Studies Revolving Fund.

Evaporites
Solid crystalline deposits of salts from seawater or salt-lakes resulting from the evaporation of the water.

Exploration well
A well drilled to test an undrilled trap or to test deeper untested zones in a trap already drilled.

Export line
The oil pipeline from the storage area in the GBS to the ALP—as opposed to flowlines.

Fault
In the geological sense, a break in the continuity of rock types.

Flare
To burn off gases not otherwise required.

Flooding
The injection of water or gas into or adjacent to, a productive formation or reservoir to increase oil recovery.

Flowline
Subsea pipeline connecting individual wells to a production manifold.

Fluvio-deltaic
Of, or produced by, the action of moving water in rivers and deltas.

Gas cap
The layer of free gas above the oil zone of a reservoir.

Gas re-injection
Process where gas is re-cycled by being returned under pressure to a producing formation in order to maintain reservoir pressure.

GBS
Gravity Base Structure. The concrete production structure fixed to the sea floor by its own weight and which supports the topsides facilities.

Greenfield facility
A new industrial facility normally requiring new infrastructure.

Graben
A large block of rock, generally long compared to its width, that has been downthrown along faults relative to the rocks on either side.

Growler
A small iceberg fragment weighing up to 200 tonnes, up to 1 metre high and up to 6 metres long. Smaller than a bergy bit.

HBP
Hibernia Benefits Plan.

HDP
Hibernia Development Plan.

Helideck
A landing platform for helicopters.

Hindcast analysis
A method of deducing the state of a given parameter at some time in the past by analysis of the meteorological data of the same period.

Inert gas blanket
A layer of non-reactive gas (e.g. nitrogen) placed above flammable liquids in enclosed spaces to prevent the formation of explosive or flammable mixtures which would result if the space was air-filled.

Injection
The process of pumping gas or water into an oil-producing reservoir to provide a driving mechanism for increased oil production.

Intercalated
Something interposed within something else.

Isopach map
Geological map with lines showing equal thicknesses of the same formation.

J-Tube
The section of pipe, shaped like the letter J, that connects the piping of an offshore production platform to a seabed pipeline.

Jurassic
The second and middle period of the Mesozoic era. From 195 to 140 million years ago.

Kerogen
Organic matter disseminated in sedimentary rocks from which hydrocarbons are formed.

Limestone
A sedimentary rock composed of calcium carbonate.

Listric
With reference to faults, becoming less steep with depth.

Lithic
Sediments in which rock fragments are more abundant than feldspar grains.

Lithology
The description of the physical character of a rock as determined by eye or with a low-power magnifier, and based on colour, structure and grain size.

Logging
A systematic recording of data from the driller's log, mud log, electrical well log, or radioactivity log.

Lower Cretaceous
The older strata of the Cretaceous period.

Manifold
A piping arrangement containing the valving to flow into several parts, combine several flows, or reroute a flow to one of several possible destinations.

Mesoscale event
Atmospheric disturbances severe enough to affect activities in the relatively small area where one occurs, but too confined geographically to be detected readily by the established network of observing stations.

Mesozoic
The second (middle) major geological era. From about 230 to 65 million years ago.

Miscible flood
A secondary or tertiary oil recovery method where two or more injection fluids are used, one behind the other, for example, gas and water, to mix with the oil and enhance flow characteristics.

MSF
Main Support Frame.

Muster station
Gathering point of the crew of a vessel or platform in the event of an emergency situation.

Net pay map
A contour map depicting net thicknesses of hydrocarbon-bearing reservoirs.

NGL
Natural Gas Liquid.

NLPD
Newfoundland and Labrador Petroleum Directorate.

OGIP
Original gas in place.

OGL
Oil and Gas Lease.

Oil-base mud
Drilling mud in which oil is the continuous phase.

100-year return
An event of a magnitude that statistically is predicted not to occur more than once in a 100-year period.

OOIP
Original oil in place.

Organic
In a general sense, pertaining to or made by living organisms.

Oxygen scavenger
Substances used to react chemically with oxygen which might otherwise cause corrosion.

Pelagic
In the biological sense, living in the water column, for example, fish or plankton, as opposed to being benthic. In the geological sense, the accumulation of deep sea sediments, or the materials and organisms endemic to the marine environment as opposed to those transported in it.

Petrophysics
Study of reservoir properties from various logging methods.

Porosity
The volume of the pore space expressed as a percent of the total volume of the rock mass.

Pressure gradient
The rate of pressure increase with depth.

Produced water
Water associated with oil and gas reservoirs that is produced along with the oil and gas.

Production platform
An offshore structure equipped to produce and process oil and gas.

Production well
A well drilled and completed for the purpose of producing crude oil or natural gas.

Proponent
In this report only refers to the Hibernia Joint Venture Group (Mobil and its partners) which submitted the Development Plan and the Benefits Plan.

Rebar
Steel bars or rods placed within poured concrete for reinforcement.

Recoverable reserves
That part of the hydrocarbon volumes in a reservoir that can be economically produced.

Red bed sediments
Red coloured sedimentary rocks.

Remote sensing
Monitoring an event or phenomenon with instrumentation located at a distance from the target being observed.

Reservoir
A porous, permeable rock formation in which hydrocarbons have accumulated.

Reservoir pressure
The pressure of fluids in a reservoir.

RFT
Repeat Formation Tester. A tool which records reservoir pressures at multiple points in a well.

Sandstone
A compacted sedimentary rock composed of detrital grains of sand size.

Satellite wells
Subsea wells located remote from the production facility and connected to the facility by flowlines.

Scour
An elongated depression or trench in the seabed resulting from the ploughing action of the bottom of an iceberg or the erosive action of currents.

Sedimentary rock
Rock formed by accumulation of sediment in water or accumulation of sediments carried by air.

Seismic
Pertaining to, characteristic of, or produced by earthquakes or earth vibration, as seismic disturbances.

Shuttle tanker
A ship which regularly transports oil or other products from a production facility to an unloading facility.

Siltstone
Rock formed from indurated silt.

Spud
To start the drilling of a well.

SRP
Special Renewal Permit.

Storage displacement water
Seawater which is used to maintain a constant fluid volume in the GBS storage cells to compensate for fluctuating oil levels.

Stratigraphy
That part of geology which treats the formation, composition and correlation of stratified rocks.

Subarkose
Sandstone containing 10 to 25 percent feldspar.

Sublethal
The concentraction of a toxin which is insufficient to cause death but which may have significant harmful effects.

Sublithic
Rocks or sediments where the proportion of rock fragments is less important than the feldspar grains.

Sublithic arenite
A sandstone with a small proportion of rock fragments.

Surficial
Pertaining to the surface.

Tectonic
Relating to the deformation of the earth's crust and the associated structural changes in rocks.

Tertiary
The earlier of the two geologic periods comprising the Cenozoic era. From 65 to 18 million years ago.

Thermocline
The level which separates the upper, warmer and lighter water from the underlying cooler, heavier water. The upper waters, being warmer and well lit, are very important for the production of plankton upon which most marine life ultimately depends.

Topsides
The structures above the water on a production platform.

Transverse fault
A fault whose strike is more or less perpendicular to the general structural trend of the region.

Triassic
The earliest of the three periods of the Mesozoic era. From 230 to 195 million years ago.

Toxicity
The degree to which a toxin is harmful.

Toxin
Any substance which in sufficient quantity is harmful to biota.

Unconformity
A break in the stratigraphic sequence caused either by erosion or nondeposition of sediments.

Water-base mud
A drilling mud in which the continuous phase is water.

Weather deck
Deck on top of topside structures functioning, in part, as a roof.

Wellhead
The equipment installed on the top of the well.

Workover
Operations on a producing well to restore or increase production.

Appendix C Metric Conversion Table

SI unit	Name	Symbol	Multiplication Factor	Imperial Unit
Length	nanometre	nm	39.37×10^{-9}	= inch (in.)
	micrometre	μm	39.37×10^{-6}	= inch (in.)
	millimetre	mm	39.37×10^{-3}	= inch (in.)
	metre	m	1.09	= yard (yd.)
			3.28	= feet (ft.)
	kilometre	km	0.62	= mile (mi.)
Area	square metre	m^2	10.76	= square foot (sq. ft)
	hectare	ha	3.86×10^{3}	= square mile (sq. mi.)
			2.47	= acre (A.)
	square kilometre	km^2	0.39	= square mile (sq. mi.)
			247	= acre (A.)
Volume	litre	L	0.22	= Imp. gallon (gal.)
			35.20	= Imp. fluid ounces (oz.)
	cubic metre	m^3	6.29	= petroleum barrel (bbl.)
			35.31	= cubic foot (cu. ft.)
Velocity	metres per second	m/s	2.24	= miles per hour (M.P.H.)
			1.94	= knots (kt.)
	kilometres per hour	km/h	0.62	= miles per hour (M.P.H.)
			0.54	= knots (kt.)
Mass	nanogram	ng	2.20×10^{-12}	= pound (lb.)
	microgram	μg	2.20×10^{-9}	= pound (lb.)
	milligram	mg	2.20×10^{-6}	= pound (lb.)
	gram	g	2.20×10^{-3}	= pound (lb.)
	kilogram	kg	2.20	= pound (lb.)
	tonne	t	0.98	= long ton (T)
Energy	Joule	J	0.95×10^{-3}	= British Thermal Unit (B.T.U.)
	kiloJoule	kJ	0.95	= British Thermal Unit (B.T.U.)
Pressure	Pascal	Pa	0.145×10^{-5}	= pounds per square inch (psi)
			1.0×10^{-6}	= bar
	kiloPascal	kPa	0.145	= pounds per square inch (psi)
			1.0×10^{-2}	= bar
Temperature	degrees Celsius	°C	(1.8 x °C) + 32	= degrees Fahrenheit (°F)

Appendix D

Overview of the Hibernia Development Plan

PREFACE

The Hibernia Development Plan Overview has been prepared by Mobil Oil Canada, Ltd. on behalf of, and in cooperation with, the joint venture participants: Gulf Canada Resources Inc., Petro-Canada Inc., Chevron Canada Resources Limited, and Columbia Gas Development of Canada Ltd.

The plan is based on information and design work available to July 1985 and may be modified or refined as further information becomes available. This document does not constitute a commitment by the participants to proceed with the development of the Hibernia Field.

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APPENDIX D

HIBERNIA DEVELOPMENT PLAN OVERVIEW

1.1 INTRODUCTION

Mobil Oil Canada, Ltd., on behalf of the joint venture participants, plans to develop the Hibernia Field on the northeastern Grand Banks. The Hibernia Field is about 315 km east-southeast of St. John's, Newfoundland (Figure 1.1-1) in approximately 80 m water depth. The project is called the Hibernia Development Project and consists of producing oil from both platform and subsea wells, treating the oil on a gravity base structure (GBS) production platform to remove produced water and gas, storing the treated oil in the GBS, and transporting the oil to market with tankers. The scope of this project includes construction and installation of production and storage facilities, development drilling, operation and maintenance of production facilities, transportation of oil, and decommissioning of the facilities.

The Hibernia Development Plan constitutes a plan by which development of the Hibernia Field will take place. Changes to this plan may be necessary as a result of the detailed design process and as further information is developed.

1.2 GEOLOGY

The geological and geophysical interpretations of the Hibernia Field are based upon the integrated results of extensive seismic coverage and a ten-well data base.

The Hibernia Field lies on the western edge of the Avalon Basin (Figure 1.2-1). The Avalon Basin is bounded to the west by the Bonavista Platform, to the east by the Ridge Complex, to the south by the Jeanne d'Arc Sub-Basin, and to the north it opens into the East Newfoundland Basin. The major hydrocarbon accumulations of the Hibernia Field occur within a dominantly paralic sequence in the Lower Cretaceous section. The structural trap for the hydrocarbon accumulations is formed by a large

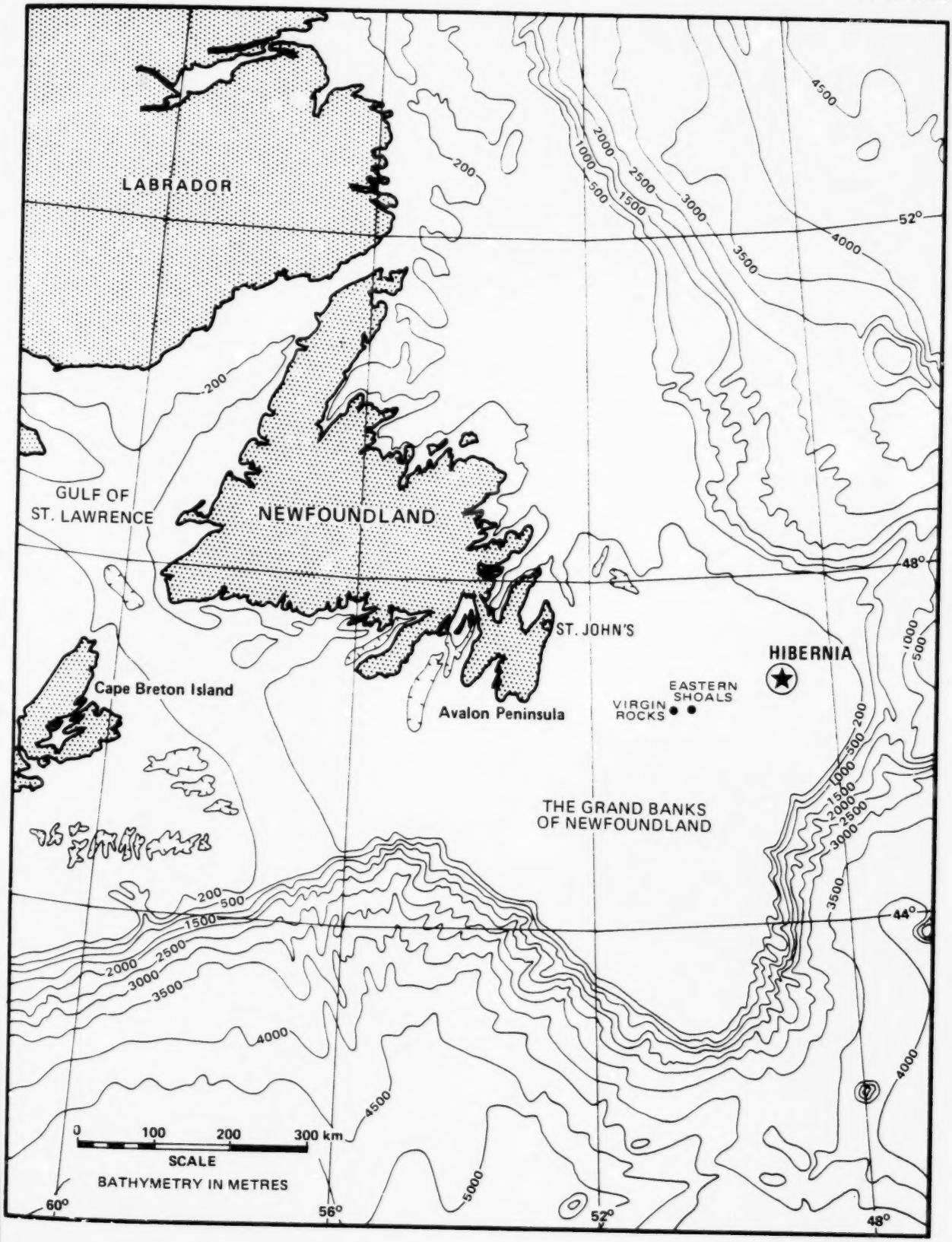

LABRADOR
GULF OF
ST. LAWRENCE
NEWFOUNDLAND
ST. JOHN'S
HIBERNIA
Cape Breton Island
Avalon Peninsula
EASTERN
SHOALS
VIRGIN
ROCKS
THE GRAND BANKS
OF NEWFOUNDLAND
200
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
52°
48°
44°
0 100 200 300 km
SCALE
BATHYMETRY IN METRES
60°
56°
52°
48°

FIGURE 1.1-1

BATHYMETRY AND TECTONIC ELEMENTS

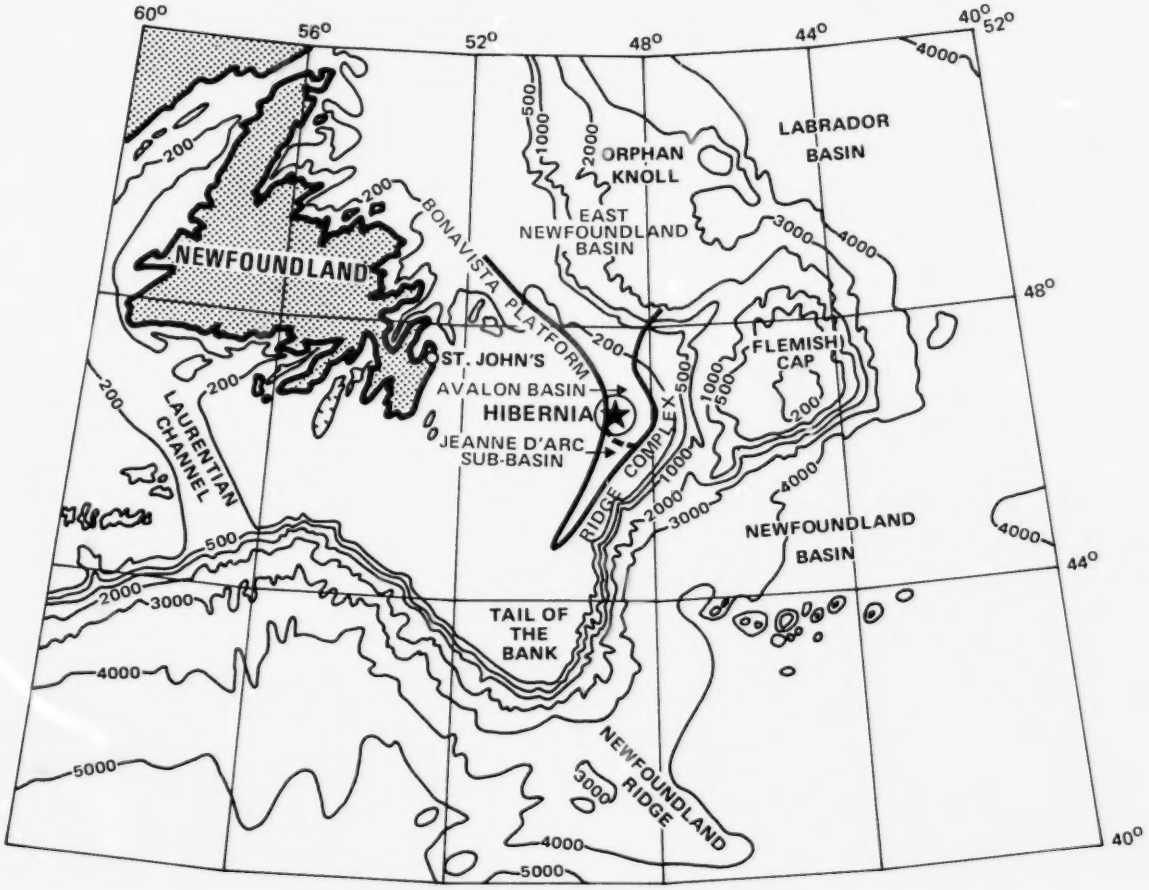


FIGURE 1.2-1

rollover anticline that is bounded to the west by a major listric normal growth fault, the Murre Fault, which separates the structure from the stable shelf area to the west.

1.2.1 Reservoir Stratigraphy and Facies

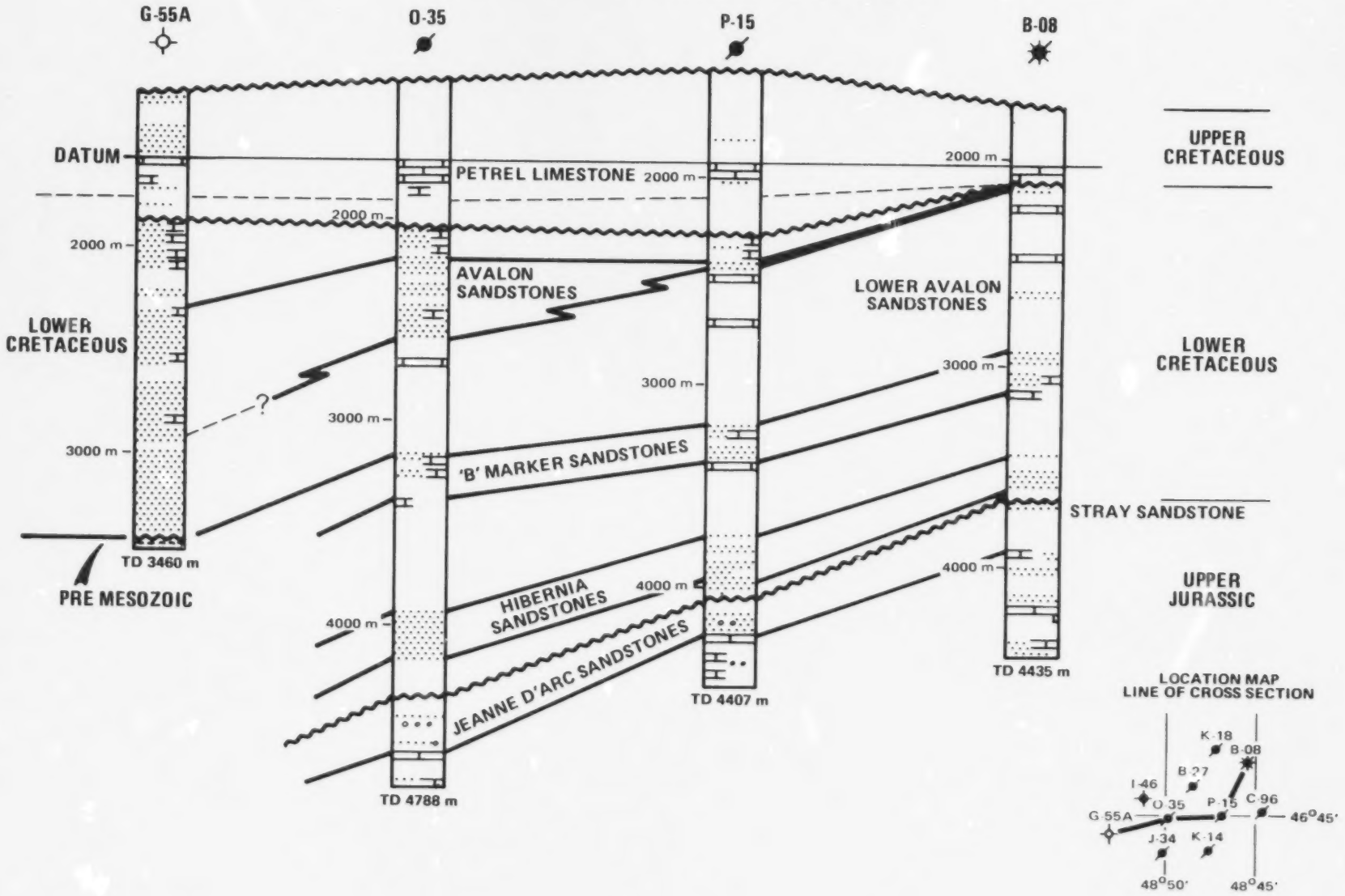
The two principal reservoirs of the Hibernia Field are the Hibernia and Avalon Sandstones. The field also contains four subordinate reservoirs: the Jeanne d'Arc, Hibernia Stray, 'B' Marker, and Lower Avalon Sandstones. Figure 1.2-2 shows the stratigraphic relationships of these reservoirs.

In ascending order, the reservoir sandstones show increasing evidence of a marine transgression. This transgression is reflected in an upwardly decreasing mean grain size, and facies assemblages that range from fluvial in the Jeanne d'Arc through fluvio-deltaic in the Hibernia, to shallow marine in the 'B' Marker and Avalon.

The Hibernia Sandstones, subdivided into three sandstone layers and a medial shale zone, are interpreted as a fluvial-deltaic sequence in which a system of distributary channels trend predominantly northeast-southwest. Lateral continuity of the reservoir sandstones is postulated as being achieved through lateral migration of channels and their associated sand bodies; vertical continuity, through stacking of channel sands by successive incision into pre-existing channel deposits.

The Avalon Sandstones, subdivided into four sandstone layers and two shale markers, are interpreted as a sequence of offshore bars, storm deposits, and sheet-type sands that were deposited in dominantly low-energy marine and marginal marine environments that were episodically subjected to increased energy levels attributable to storm activity. Depositional strike is in a general north-south direction. Thin bed stratigraphy predominates. The overall extent of lateral and vertical continuity of the reservoir sandstones is uncertain. Potential impediments to reservoir continuity include zones of bioturbation and zones of calcite cementation.

HIBERNIA STRATIGRAPHY



The subordinate reservoirs are characterized by relatively thin pay zones and, with the exception of the 'B' Marker, are single well hydrocarbon occurrences. The highly stratified sequence of the 'B' Marker exhibits a complicated and apparently unconnected system of fluid interfaces.

1.2.2 Structural Geology

The major structural elements associated with the Hibernia anticline are the Murre Fault, the Nautilus Fault, and a complex internal system of faults that deform the anticline (Figures 1.2-3 and 1.2-4). The system of faults that distort the anticline can be loosely grouped into two sets, distinguished by differences in strike. For convenience, these sets are referred to as the "transverse set" and the "oblique set."

The transverse set strikes northwest-southeast, transverse to the strike of the Murre Fault and the trend of the crestal portion of the Hibernia anticline. Vertical offsets of the stratigraphic section are measured in hundreds of metres or less.

The oblique set has faults that strike in a more north-south direction than the faults of the transverse set. Generally, this set of faults demonstrates less vertical offset of the stratigraphic section than the transverse set.

The significance of faulting upon reservoir continuity is unknown at this time. The sealing or non-sealing nature of the faults cannot be accurately determined until after the field has been on production.

1.3 RESERVOIR ENGINEERING

1.3.1 Principal Reservoirs

Petrophysical and well test data indicate that the Hibernia Sandstones are of good reservoir quality, but that the reservoir is complicated by a substantial amount of major and minor faulting. The Hibernia Sandstones contain an original gas cap, tested in the B-08 well only.

Petrophysical and well test data indicate the Avalon Sandstones to be fairly heterogeneous with a high degree of stratification. Compared to the Hibernia Sandstones, the Avalon Sandstones are of poorer reservoir quality. Like the Hibernia Sandstones, the Avalon Sandstones are complicated by numerous major and minor faults. Due to the relatively poor permeability in the west and thin net pay in the north and east, the possible area of future Avalon development is limited. Table 1.3-1 summarizes the reservoir properties for the Hibernia and Avalon Sandstones.

1.3.2 Subordinate Reservoirs

Four subordinate hydrocarbon bearing reservoirs have been identified: 'B' Marker, Hibernia Stray, Lower Avalon, and Jeanne d'Arc Sandstones. Primarily due to pressure depletion observed in well tests performed on the subordinate reservoirs, potential resources are only assigned to the designated K-18 'B' Marker Sandstones. Even so, the occurrence of hydrocarbons in the 'B' Marker is at best sporadic in nature.

1.3.3 Basic Reservoir Data

Extensive data were gathered on the ten wells drilled in the Hibernia Field. The logs, cores, and fluid samples were analyzed to derive permeability, relative permeability, porosity, capilliary pressure, compressibility, water saturation, and fluid property values. In addition, a series of slim tube gas-oil experiments indicated some possibility of miscible displacement in the Hibernia Sandstones.

1.3.4 Development Strategy

The proposed development comprehends total development of the Hibernia Sandstones and possibly a portion of the Avalon Sandstones which will be determined by reservoir and well production performance, and economics. The possible area of future Avalon development is indicated in Figure 1.2-4. The proposed production system is designed to produce a nominal rate of 24×10^3 m^3/d of stock tank oil. The Hibernia Sandstones will be developed first.

TABLE 1.3-1

SUMMARY OF RESERVOIR PROPERTIES

	Hibernia Sandstones	Avalon* Sandstones	Typical Value	
			Hibernia Sandstones	Avalon* Sandstones
Areal extent (ha)	6703	1788		
Net pay (m)	28.7 - 68	23.5 - 71.9	46	31
Porosity (%)	14.5 - 18	18.0 - 22	16	20
Permeability (mD)	150 - 2000	30 - 500	400	150
Original oil in place (10^6 m^3)	214**	104**		
Proposed recovery mechanisms	Gas and waterflood	Waterflood		
Degree of stratification	Moderate	High		
Degree of faulting	High	High		
Reservoir datum (m SS)	3544	2476		
Reservoir pressures at datum (MPa)	39.5	26.7		
Reservoir temperatures at datum (°C)	95	66		
Bubble points (MPa)	32 - 40	18 - 25		
Reservoir oil viscosity (mPa s)	0.37 - 0.72	0.90 - 1.67		
Projected recovery factors (%)	33**	11**		
Peserves (10^6 m^3)	71**	12**		

*Possible area of future development.

**Likely values.

If feasible, reservoir pressure will be maintained during production by a combination of water and gas injection into the Hibernia Sandstones and by water injection into the Avalon Sandstones. Produced gas will be injected into the crestal areas and water will be injected into the downdip areas of the Hibernia Sandstones. The Avalon Sandstones may be developed with subsea wells when the productive capacity of the Hibernia Sandstones declines below the throughput capacity of the production system.

Full-field development as currently envisaged will require an estimated 83 wells. Average well spacing will be about 100 ha in the Hibernia Sandstones and 70 ha in the Avalon Sandstones.

1.3.5 Original Gas In Place

Table 1.3-2 shows the original gas in place for full field development of the Hibernia sandstones and for the possible area of future Avalon development. Approximately 30 percent of the Hibernia gas is contained in a primary gas cap.

1.3.6 Production Forecast

An annual average production forecast for the proposed development area is shown in Figure 1.3-1 for the likely reserves of 83×10^6 m^3. The production decline portion of the forecast is derived from areal reservoir simulation studies.

1.3.7 Reservoir Management

The data acquisition system planned for the Hibernia and Avalon Sandstones will include bottomhole pressure surveys, produced fluid composition monitoring, open hole and cased hole logs, cores, and production and injection well tests. The system will yield the information required for management of the reservoirs.

TABLE 1.3-2

ORIGINAL GAS IN PLACE
AVALON AND HIBERNIA SANDSTONES

Sandstones	Solution Gas (10^9 m^3)	Gas Cap (10^9 m^3)	Total (10^9 m^3)
Avalon			
Possible area of future Avalon development	9.1	-	9.1
Hibernia			
Full field development	46.5	18.8	65.3

1.4 PHYSICAL ENVIRONMENT

1.4.1 Data Base

Estimates of extreme values associated with each of the environmental parameters have been prepared for Hibernia. These estimates will be updated periodically if and when new environmental data become available. Three primary sources of data have been used:

(1) Hibernia-specific hindcast studies, literature surveys, and data collection programs (including rig observations over the past 5 years)
(2) Weather data for St. John's
(3) Other relevant data from government institutions and scientific organizations

Parameters characterizing the range of environmental conditions experienced at Hibernia were obtained by applying standard statistical analyses to the available data. Generally, the data base that is available for these analyses is too short to allow accurate prediction of extremes. However, the data base does serve to calibrate and verify the analyses of both extreme and normal conditions determined by hindcast methods. In a few instances where an adequate hindcast data base could not be constructed, other analysis techniques such as empirical modelling and random simulation have been used.

1.4.2 Meteorology

Monthly mean air temperatures recorded at Hibernia range from -0.5°C in February to 13.5°C in August. These compare with monthly mean temperatures at St. John's of -4.5°C for February to 15.5°C for July.

At St. John's, the greatest recorded 24-hour rainfall is 121 mm and the greatest 24-hour snowfall is 55 cm. These values are probably more extreme than at the Hibernia site because of the influence of land masses.

Table 1.4-1 gives the extreme wind speeds for the Hibernia area.

TABLE 1.4-1

EXTREME WIND SPEED

Return Period (years)	Average Wind Speed at 10 m Elevation Simultaneous with Maximum Wave Heights			
	1 h (m/s)	10 min (m/s)	1 min (m/s)	3 s (m/s)
1	23.2	24.7	30.0	33.2
10	28.5	30.2	34.7	40.7
25	30.9	32.8	37.7	44.2
50	32.7	34.6	39.9	46.7
100	34.5	36.5	42.1	49.3

Visibility is best in fall and poorest in early summer. Poor flying conditions (due to poor visibility, low ceiling, and more severe weather conditions) occur most frequently during late winter and early spring.

Sea spray icing may occur, particularly on supply and tanker vessels. Atmospheric icing will be more likely to accumulate above the spray zone on the production platform and articulated loading platforms (ALP's). Significant icing has not occurred on floating drilling units used for exploration drilling on the Grand Banks. The highest probability of icing conditions exists in February when severe icing is estimated to occur almost 2 percent of the time.

1.4.3 Oceanography

Extreme current speeds, based on a 100-year return period, have been estimated to range from 1.69 m/s at the surface to 0.66 m/s near the sea floor.

Extreme surface seawater temperatures are estimated as 15.6 and -2.5°C, and the extreme temperatures at a depth of 75 m are estimated as 7.8 and -1.7°C.

Table 1.4-2 gives the extreme wave heights and peak periods for Hibernia.

TABLE 1.4-2

EXTREME WAVE PARAMETERS FOR HIBERNIA

Return Period (years)	Significant Wave Height H_s (m)	Maximum Wave Height H_{max} (m)	Peak Period of Wave Spectrum T_p (s)
1	10.3	21.0	12.5
10	13.0	23.9	16.4
25	14.2	26.1	17.0
50	15.1	27.8	17.5
100	15.9	29.3	17.9

At Hibernia, the extreme astronomical tidal range is estimated to be 1.0 m, and the extreme storm surge elevation, 0.7 m.

1.4.4 Ice

Sea ice has drifted into the Hibernia area during 6 of the 27 winters between 1959 and 1985. The average ice concentration increases from early January to a maximum of 7/10 in mid-March, and ice fully covers the area only in extreme conditions. Ice has remained in the area for a maximum of 6 weeks, while the mean duration has been about 2 to 3 weeks. Mean floe diameters are approximately 4 m and range up to 18 m, with mean ice thicknesses ranging from less than 1 m for small floes to 2.7 m for rafted floes. Average drift speeds of sea ice have been measured in the range of 0.2 to 1.0 m/s.

An annual average of 30 icebergs pass through the degree square (76 km by 111 km) containing the Hibernia Field, although there is a high variability in the number of icebergs from year to year. While the general drift of icebergs over a period of days can be reasonably well defined, localized behaviour over short time intervals is more difficult to predict. Data collected to date give a mean drift speed of 0.25 m/s and a maximum speed

greater than 1.0 m/s. For icebergs (with drafts of 90 m or less) which might drift into the Hibernia area, the mean mass is about 0.3×10^6 t. The largest iceberg which could drift into the Hibernia area is estimated to be approximately 6×10^6 t.

Severe storms rarely occur during the iceberg season, resulting in a very low probability of the joint occurrence of a severe storm and an iceberg impact.

1.5 GEOTECHNICAL ENGINEERING

The geotechnical data base consists of soil borings, geophysical data, and iceberg scour and pit data.

1.5.1 Physiography and Bathymetry

The proposed offshore facilities site is located on the northeastern Grand Banks approximately 75 km from the edge of the bank. Water depths in the Hibernia Field range from 78 to 84 m. The area is relatively featureless with relief of about 0.5 m, and seafloor slopes of less than 0.8 percent or 0.5 degrees.

1.5.2 Geological Description

The bedrock geology of the Grand Banks has been divided into three units. Undifferentiated late-Precambrian metamorphic rocks extending seaward from the Avalon Peninsula are exposed at or near the seabed in the Virgin Rocks - Eastern Shoals area (Figure 1.1-1). These are overlain by well-indurated Cambrian to Devonian rocks in the area between the Avalon Peninsula and the Virgin Rocks. These, in turn, are overlain by Cretaceous and Tertiary rocks that extend over the southern and eastern portions of the Grand Banks, including the facilities site, to the edge of the continental shelf. The Tertiary rocks are primarily semiconsolidated siltstones, mudstones, and sandstones. Thin Quaternary deposits, consisting mainly of reworked sand and gravel and some glaciomarine sediments, cover the Hibernia Field.

Natural seabed features at the offshore facilities site include megaripples, an iceberg scour, and a number of linear furrows.

The maximum depth of documented scours in the Hibernia area is 1.6 m with a maximum scour frequency of 0.074 per square kilometre, and 0.039 per linear kilometre. A pit feature approximately 10 m deep has been documented about 12 km east of the proposed GBS location.

1.5.3 Geologic Processes

The Grand Banks region lacks young tectonic features and has had a low rate of tectonic activity over a long period. Operating level earthquakes (the level of extreme earthquake ground motion that could normally be expected during the life of an offshore structure) may produce accelerations of 0.3 m/s^2 and peak ground velocities of 0.4 to 3.0 cm/s (depending on the method of calculation used). These parameters for safety level earthquakes (the maximum level of ground motion that could reasonably be expected at the site) are predicted as 0.98 m/s^2 and 13 cm/s respectively for the near-field event and 0.49 m/s^2 and 18 cm/s respectively for the far-field event. These values pertain to horizontal components. Vertical motions are estimated to be two-thirds of the corresponding horizontal values.

A shallow geophysical survey revealed no active faulting at the Hibernia site. Liquefaction analysis indicates a low potential for soil liquefaction; seismic excitation levels are low and deposits are dense and granular.

Some sedimentary bedforms including sand ripples, megaripples, sand waves, sand ribbons, and sand ridges exist in the Hibernia area.

1.5.4 Geotechnical Properties

The boreholes drilled in the Hibernia Field to investigate soil conditions indicate dense, predominantly granular strata occasionally separated by thin, hard clay layers. These are underlain by hard, cohesive layers.

The engineering properties of the granular and cohesive material fall within a narrow range. The high cone-point resistances of the granular soils, particularly from 0 to 20 m penetration, coupled with the high shear strengths of the cohesive soils, indicate that the soils are overconsolidated and that lateral in situ stresses are relatively high.

Based on preliminary design parameters, geotechnical conditions at the site appear favourable for installation of the GBS, the ALP's, and the export pipeline. Pile foundations, which may be required for some subsea equipment, are also considered feasible.

1.6 PRODUCTION AND TRANSPORTATION SYSTEMS

1.6.1 Development Concept and Design Criteria

The proposed production system will be designed to produce at a nominal rate of 24×10^3 m^3/d of stock tank oil. Figure 1.6-1 illustrates the development concept and shows the terminology used to describe the facilities. Table 1.6-1 summarizes the functional design criteria for the proposed production system. The production platform will consist of top-side facilities mounted on a GBS. Both platform and subsea wells will be utilized. Subsea wells will be tied to the platform directly or through production manifolds or headers. The transportation system will consist of an export line, two ALP's, and three purpose-built shuttle tankers.

Production of gas for sale is not considered part of the Hibernia Development Project. It is proposed that gas be conserved by injection into the Hibernia Sandstones.

1.6.2 Gravity Base Structure

The GBS will consist of three components: a concrete base slab, a caisson reaching from the seabed to approximately 5 m above mean low water level, and four shafts extending above the caisson. The entire structure will be constructed from high-strength, reinforced concrete. The ballast for the GBS will include both water ballast and solid ballast (iron ore or other

PRODUCTION SYSTEM COMPONENTS

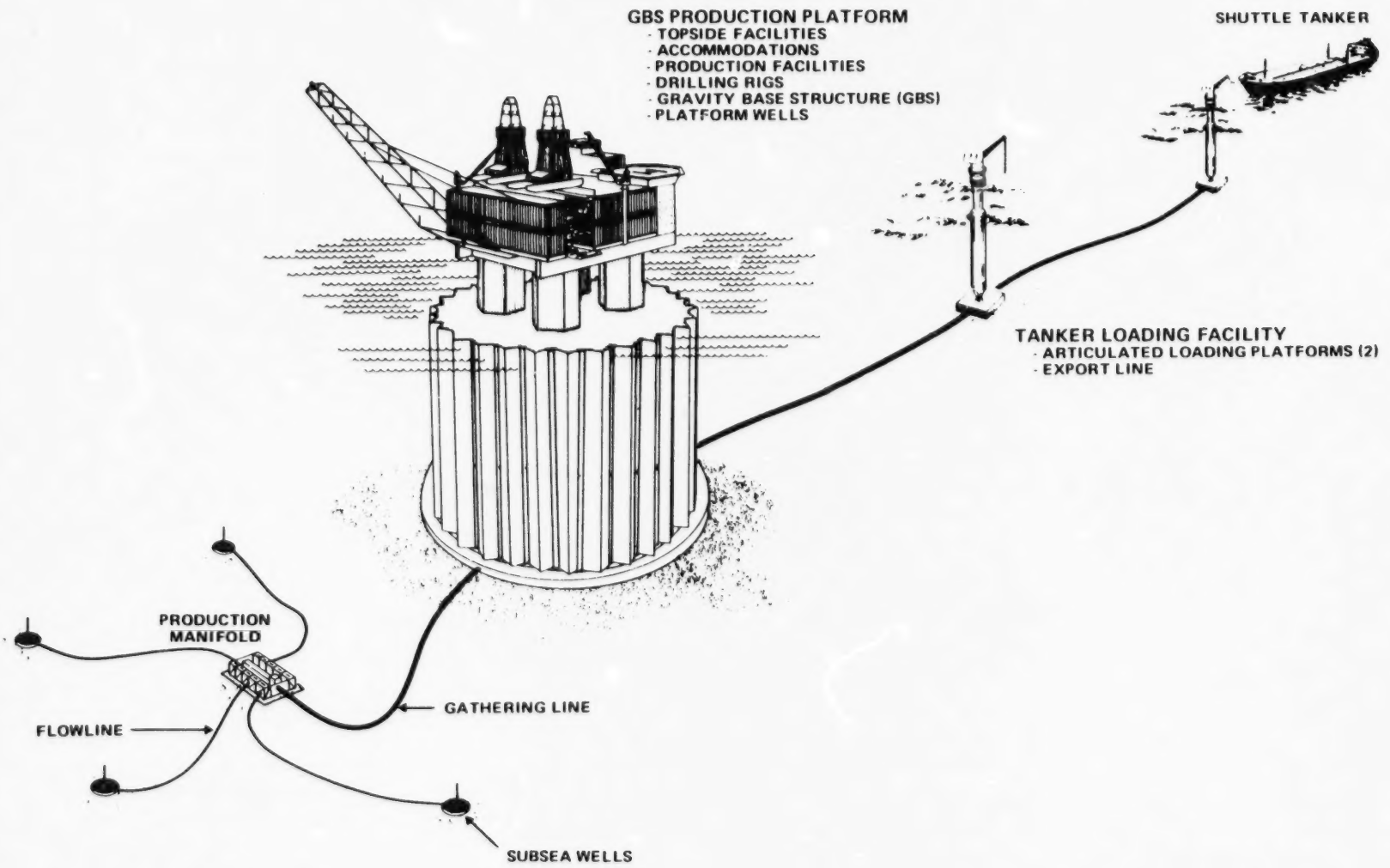


TABLE 1.6-1

FUNCTIONAL DESIGN CRITERIA

Criterion	Value
Total Field Nominal Design Rates	
Oil production rate (m^3/d)	24.0×10^3
Water production rate (m^3/d)	12.7×10^3
Total fluid production rate (m^3/d)	33.4×10^3
Water injection rate (m^3/d)	35.0×10^3
Gas production rate (m^3/d)	7.4×10^6
Gas injection rate (m^3/d)	6.7×10^6
Fuel gas consumption rate (m^3/d)	0.7×10^6
Gas-lift gas rate (m^3/d)	0.8×10^6
Injection Pressures	
Maximum design gas injection pressure (MPa)	41.4
Maximum design water injection pressure (MPa)	24.1

Platform and Subsea Wells	Avalon Sandstones	Hibernia Sandstones
Number of platform production wells	0	30
Number of subsea production wells	16	3
Number of platform water injection wells	0	12
Number of subsea water injection wells	9	7
Number of platform gas injection wells	0	6
Maximum vertical well depth (m)	2750	4150
Maximum bottomhole pressure (MPa)	29.0	44.0
Maximum design production wellhead pressure (MPa)	22.0	31.0
Maximum design water injection pressure (MPa)	24.1	24.1
Maximum design gas injection pressure (MPa)	-	41.4
Average subsea wellhead flowing pressure (MPa)	4.9	11.0
Average platform wellhead flowing pressure (MPa)	2.4	7.6
Maximum design production well total fluids (m^3/d)	1.9×10^3	4.8×10^3
Maximum design water injection rate per well (m^3/d)	3.2×10^3	6.4×10^3
Maximum design gas injection rate per well (m^3/d)	-	2.3×10^6
Maximum design gas-lift gas rate per well (m^3/d)	57×10^3	-
Maximum reservoir temperature (°C)	72	105
Average wellhead flowing temperature (°C)	51	78
Design maximum wellhead temperature (°C)	72	105

Notes:
1. Numbers are preliminary and subject to revision.
2. All rates are measured in units per stream day.
3. All gas volumes are measured at standard conditions (101.3 kPa and 15°C).

loose, high density material). Table 1.6-2 summarizes approximate dimensions and capacities of the GBS.

Four shafts (two drill shafts, a riser shaft, and a utility shaft) will support the topside facilities. Provision will be made for up to 32 platform wells through each of the two drill shafts. The GBS will contain complete oil storage and pumping systems and will support risers for intra-field pipelines.

The GBS will be designed to meet all environmental and geotechnical conditions at the facilities site. The GBS design will provide global resistance for the environmental loads from all directions, including those loads associated with combined events (e.g. waves and icebergs).

1.6.3 Topside Facilities

The topside facilities will include production, utility, drilling, electrical, and personnel support systems. The topside facilities will consist of three levels: the cellar deck, the module deck, and the weather deck.

Cellar Deck

The cellar deck will consist of a main support frame (MSF) accommodating utility and process equipment. The MSF will be an open steel truss structure, supporting all facilities above the concrete columns.

Module Deck

The module deck will contain process, utility, and drilling facilities in modules supported on the MSF. Approximately 16 modules ranging in size from 12 m x 26 m x 28 m high to 18 m x 34 m x 21 m high will occupy the module deck. The modules will contain gas compression, gas injection, wellheads, drilling fluids, water injection, power generation, and accommodation facilities. A 300-bed accommodation module will be located at one end of the topside facilities.

TABLE 1.6-2

APPROXIMATE DIMENSIONS AND CAPACITIES
GRAVITY BASE STRUCTURE

Dimensions	Value
Height above seafloor	105.0 m
Penetration into seabed	0.5 m
Base slab diameter	105.0 m
Overall caisson diameter	100.0 m
Height of caisson above seafloor	85.0 m
Minimum centre-to-centre distance between shafts	29.5 m
Height of skirts	0.5 m
Number of oil storage cells	28
Total oil storage volume	230×10^3 m^3

Weather Deck

The top of the modules on the module deck will serve as the weather deck. Equipment located on the weather deck will include two drilling derrick and substructure assemblies, drill pipe racks, and drilling-office modules.

1.6.4 Subsea Installations

To complete the development of the field, a number of subsea wells for production and water injection will be drilled in locations beyond the practical range of directional drilling from the GBS. Subsea wells will be connected via flowlines to either production manifolds, production headers, or directly to the GBS. All subsea wellheads will be remote from the production headers and manifolds.

The production manifolds will contain valving to commingle production from subsea well flowlines into main gathering lines. The gathering lines will connect the manifolds to the GBS. The production headers will be simplified production manifolds. The production manifolds and headers will be secured to the ocean floor by steel piles.

The subsea wells will be drilled by floating drilling units. There are three options for subsea completions: conventional wet-tree completions on the seafloor, wet-tree caisson completions, and wet-tree silo completions. The latter two are submudline completions which will be evaluated in addition to newly developing technologies before subsea wells are drilled.

1.6.5 Transportation System

The transportation system will include an export line, two ALP's, and an estimated three shuttle tankers.

The export line will transport crude oil from the GBS to either of the two ALP's located 3 to 5 km from the platform.

Each ALP will have three major components: a base, a column, and a loading head. The column is attached to the base by an articulated joint that allows the column to incline in any direction, with the buoyancy of the structure providing the upright restoring force. The loading head is mounted on a large bearing assembly to permit rotation. The base design is either a gravity or a piled steel structure. Articulated columns of similar design have been used in the North Sea since 1975.

The ALP's will withstand all environmental and geotechnical conditions anticipated at Hibernia with the possible exception of impact by a large iceberg. In the unlikely event of a direct iceberg impact, the ALP might be damaged or rendered inoperable. In this case, oil will be routed to the second ALP.

Three shuttle tankers of 120×10^3 DWT each will transport oil loaded from the ALP's to shore. Each of the shuttle tankers will have cargo-receiving facilities at the bow, and the accommodations and engine room at the stern. The hull structures will be ice strengthened in accordance with relevant design codes. Special strengthening measures are being developed to prevent damage from collision with pieces of glacial ice too small to be reliably detected.

1.6.6 Decommissioning

When the Hibernia Field has been depleted, decommissioning and site restoration will be carried out in accordance with applicable regulations in effect at that time. Approval will be sought to selectively abandon wells throughout the life of the field as individual wells become uneconomic to operate. Wells will be abandoned by installing cement plugs and mechanical bridge plugs, and removing all equipment above the seafloor.

1.6.7 Production Safety

All components of the production system will be equipped with comprehensive safety systems to monitor the production process and ensure

that safe operating parameters are maintained. When conditions dictate, appropriate protection will be initiated by the safety systems to shut down or otherwise control the process. Safety systems will include fire suppression, fire and gas detection, emergency shutdown, well control, ventilation, and alarm annunciation.

1.7 CONSTRUCTION AND INSTALLATION

1.7.1 Schedule

Figure 1.7-1 shows a tentative schedule for the development of the Hibernia Field. The schedule assumes all governmental agreements are in place early in 1986, resulting in an estimated start of oil production in 1992.

1.7.2 Production Platform

Gravity Base Structure

The GBS will be constructed from reinforced and post-tensioned concrete. Construction of the GBS will commence in a dry dock, where the large base raft will be built (Figure 1.7-2). An onshore construction area will be required for prefabrication and preassembly of components and equipment packages for mechanical outfitting of the GBS. When the base slab is completed, construction of the exterior wall will begin using slip-forming techniques.

Following completion of the base raft to an elevation of about 15 m, the structure will be towed from the dry dock to an inshore deepwater site. After the structure is moored at the site, construction will continue on the interior partition walls and the exterior wall. This phase of construction will require a floating concrete batch plant, work barges, and support facilities.

As the exterior wall is constructed, the capacity of the GBS to accept additional weight will increase, and concrete will be added to increase

the thickness of the base slab, followed by placement of some solid ballast. Mechanical outfitting will be installed after the walls are formed to the top of the caisson. The top closure slab will be poured and the four shafts extended by slip-forming up to the ring transition pieces at a height of approximately 105 m. The topside facilities will be mated to the ring transition pieces.

Topside Facilities

The MSF will be a welded steel frame structure built from prefabricated sections of the largest size practical. These sections will be assembled at an onshore assembly yard (Figure 1.7-3). The fully assembled MSF will be outfitted with preassembled equipment packages.

Concurrent with construction of the MSF, modules containing the remaining topside facilities will be fabricated at several fully equipped fabrication yards. The modules will consist of welded-steel, framed-box structures housing production equipment, drilling equipment, and accommodations. Modularization will spread the workload among several fabricators to enable work to be done concurrently and maintain the project schedule.

Following outfitting, the MSF will be relocated to a topside assembly site (at an inshore location) and placed on previously prepared concrete plinths simulating the tops of the GBS shafts. The modules will then be loaded onto the MSF using a heavy-lift crane barge. The topside assembly site will be a location immediately adjacent to shore, and reasonably close to the deepwater site. Hook-up and mechanical installation activities will be completed to the maximum degree possible while the topside facilities are located at the topside assembly site.

Barges and an arrangement of high-powered tugboats will transport the topside facilities to the deepwater site. During the mating operation, the topside facilities will be floated into position over the GBS shafts and the GBS deballasted to shift the load from the transport barges to the GBS.

Installation

Following hook-up and commissioning activities at the deepwater site, the production platform will be towed to the Hibernia Field using five or more large tugboats. Once on location, the GBS will be ballasted down to establish contact with the seafloor. Approximately 300 x 10^3 t of solid ballast (transported by large self-unloading ships) will be installed in the GBS to complete the installation.

1.7.3 Articulated Loading Platforms

The ALP bases will be fabricated from heavy steel weldments in a graving dock or slipway. Heavy-walled, tubular structures will be fabricated horizontally in semi-integrated sections, which will then be assembled to form the column bodies. The loading heads will be welded steel structures complete with mechanical outfitting. All of the ALP components will be fabricated separately at one (or more) onshore site, such as a shipyard, which permits marine transportation. The components will be assembled in the water at a suitable deepwater site.

Each completed ALP will be towed to the field, and will then be positioned and lowered to the sea bed by adding ballast. Piles will be installed if necessary, and the ALP bases will be connected to the export line.

1.7.4 Subsea Facilities

Production Manifolds and Headers

The production manifolds will be fabricated as modules using construction methods and sites similar to those discussed in Section 1.7.2 for topside modules.

After fabrication and testing, the production manifolds and headers will be transported by barge to the Hibernia site. The modules will be removed from the barge and lowered to the seafloor by crane. After each manifold

is lowered to the seafloor and secured with piles, seafloor connections will be made to the subsea wells and intra-field pipelines.

Intra-Field Pipelines

All steel pipe for pipelines will be coated externally, and internally if necessary. Flexible pipe may also be used to interconnect wellheads with subsea manifolds or directly with the production platform. Flowlines may be fabricated in cased bundles at a shore-based facility.

The pipeline program will require a storage, fabrication, and handling yard located on a waterfront with good access by road. The site may require concrete-coating facilities to coat the carrier pipes (if needed for flowline stability).

Several methods are possible for installation of intra-field pipelines. The choice of a pipeline installation method will be based on pipeline design, technical suitability, equipment availability, and cost.

1.7.5 Shuttle Tankers and Marine Support Vessels

Purpose-built vessels will be constructed for use as shuttle tankers and an ice clearing and support vessel will be purpose built. If practical, existing vessels will be used as supply and standby vessels. Typical shipbuilding facilities, practices, and skills will be required to construct or modify the marine vessels. The shuttle tankers and some of the support vessels will be ice strengthened.

1.8 DEVELOPMENT DRILLING, COMPLETION, AND WORKOVER

1.8.1 Development Drilling

An estimated 48 platform wells will be drilled into the Hibernia Sandstones by two rigs on the production platform. In addition, an estimated 35 subsea wells may be drilled by floating drilling units and completed with individual wellheads. As presently planned, 10 of these 35

subsea wells will be required to complete the development of the Hibernia Sandstones. The remaining 25 subsea wells may be required to develop the Avalon Sandstones.

For Hibernia platform wells a maximum angle of 55° from the vertical is considered practicable. The platform wells will be completed with conventional wellheads located on the GBS. Subsea wells will be completed using conventional wet-tree wellheads or submudline wellheads installed in silos or caissons. Wellheads and trees will be rated for 34.5 MPa for production and water injection wells, and 69 MPa for gas injection wells.

Table 1.8-1 summarizes typical hole size and casing programs for subsea and platform wells. Well designs will provide for tubing sizes from 89 to 140 mm.

TABLE 1.8-1

TYPICAL HOLE SIZE AND CASING PROGRAMS

		True Vertical Depth Below Seafloor			
Hole Size (mm)	Casing Size (mm)	Hibernia 0°-40° Platform Wells* (m)	Hibernia 45°-55° Platform Wells* (m)	Hibernia Subsea Wells (m)	Avalon Subsea Wells (m)
914	762	90	90	90	90
660	508	275	275	275	275
444	340	1645	1645	1645	1220
311	244	3870	3335	3870	2650
216	178	-	3870	-	-

*Approximately 125 m must be added to determine total casing lengths up to the deck of the platform.

Mud logging services will be employed for all wells. Wireline logging will be run across the productive interval. Coring is proposed in key development well.

1.8.2 Completion Operations

Completions will be kept as simple as possible. The proposed completion systems will minimize completion difficulties and provide for reliable operations. Generally the wells will be completed starting with the lower layers of the sandstone intervals. If breakthrough of water or gas necessitates recompletion, the perforated layer will be isolated and a new layer opened.

Inhibited calcium chloride brines offer the best potential as an annulus fluid for well completions.

1.8.3 Well Workovers

Two categories of workovers will be performed: wireline operations, where the production tree remains in place and provides well control capability; and major workover operations, where the production tree is pulled and well control is provided by either killing the well with fluids or setting mechanical plugs in the tubing.

1.8.4 Drilling Safety

The following operating requirements for early detection and control of hazardous well conditions will be provided for all drilling programs:

- Definition of responsibilities
- Procedures for using well control equipment
- Mud system requirements to ensure availability of kill weight mud
- Flow check requirements
- Specified tripping speeds to avoid swabbing the well
- Routine checks and equipment tests to ensure well control capability
- Testing of casing and well control equipment

Data logging units will continuously monitor all drilling parameters. Formation integrity tests will be conducted as necessary. Precautionary measures will be taken to ensure that wellheads are protected during heavy

crane-lifting operations. Drilling modules will be equipped with all required safety equipment, including fire detection and protection systems, gas detection systems, and communication systems.

Relief well drilling capability, if required, would be provided by a floating drilling unit.

Simultaneous drilling and production (SDP) from the fixed platform is planned for the Hibernia Field. Operating and safety procedures will be established. SDP is now routine in North Sea operations.

1.9 PRODUCTION OPERATIONS AND MAINTENANCE

1.9.1 Organization

The operations personnel will be organized to provide a clear chain of command. Qualified personnel will be carefully evaluated, selected, and trained to ensure their competence for their job responsibilities. It is projected that approximately 1000 offshore and onshore personnel will be needed on a continuous basis over the approximate 20-year life of the field. This does not include additional service personnel required from time to time to perform facility modifications or specialized maintenance, nor crews for floating drilling units and shuttle tankers.

1.9.2 Operations and Maintenance Procedures

Operations manuals will be prepared and will include a detailed description of the primary process, ancillary, marine, and safety systems. Detailed procedures for start-up and shutdown, as well as normal environmental operating limits, will be included for various operations. The environmental monitoring and ice management procedures will be defined in the manuals. Procedures for safe and efficient production operations will be included in a loss prevention and control manual.

Alert and emergency response procedures will be developed to outline the actions, personnel, and resources necessary for dealing with all classes

of potential and actual emergencies. The procedures will be regularly updated and the appropriate personnel trained in their use.

1.9.3 Environmental Monitoring and Ice Management

Three types of environmental monitoring programs will be carried out. Compliance monitoring will ensure all environmentally related government regulations are adhered to. Effects monitoring will detect changes in the environment surrounding the project that can be attributed to the project. Operational support monitoring will provide information on the physical environment affecting daily operations.

Forecasts containing pertinent environmental information are issued up to four times daily, predicting weather conditions for the next 48 hours, with a longer term outlook for several days thereafter.

Trained personnel who will be dedicated to collection of ice and weather information will be involved with production operations. Supervisory personnel will be informed of all weather and ice conditions that may affect operations.

When necessary, an ice management plan will be implemented. This plan will identify a series of alert zones surrounding the field facilities. The alert zones will indicate appropriate resources to be focused on a potential iceberg threat. Towing and other techniques will be employed for controlling iceberg movement. During sea ice conditions, ice clearing around the ALP and other facilities may be required. An ice clearing and support vessel will have the capability to break ice up to 1 m thick on a continuous basis.

1.9.4 Logistics

An onshore supply facility located in St. John's, Newfoundland will be used for tubular storage, warehousing for equipment, and wharfage to receive, load, and unload supply vessels.

Helicopters will move personnel between St. John's and the field facilities. Supply vessels will move consumables and equipment spares as well as providing support activities such as ice surveillance and clearing, search and rescue, diving support, oil spill cleanup, and firefighting.

1.9.5 Communications

Communication systems will use multi-channel, state-of-the-art equipment with provisions for redundancy to ensure reliable communications. The systems will include a VHF radio link as the primary communications between the offshore installations, VHF marine radio for short-range offshore communications, and public address and telephone systems for intra-platform communications. Either a satellite or a troposcatter communications system will be used as the primary system for communications between the offshore installations and the shore base.

1.9.6 Production Safety

A comprehensive safety program for the Hibernia Development Project will include the elements of an overall loss prevention and control program. The program will define responsibilities and procedures including administration of the program, design controls, routine inspections, accident investigations, personnel selection and training, regulatory rules and regulations, contingency planning for an emergency, purchasing controls, and safety audits.

The production safety program will include the search and rescue resources of both the government and the oil industry. Fixed-wing aircraft, helicopters, and surface vessels will be available for a search and rescue operation. A dedicated ice clearing and support vessel will provide the primary emergency evacuation support for the production facilities. All supply vessels will contain fast rescue craft and other emergency equipment.

1.9.7 Contingency Plans

A documented offshore alert-emergency response plan will provide a system for quick communication of the essential details of an emergency or impending emergency to those who need to react immediately, and to ensure the correct response is taken to mitigate the threat. Several government agencies are involved with the petroleum industry in providing the most effective response capability for offshore emergencies. Additionally, local operating companies have formulated a number of coordinated contingency plans using a common code and class system for various emergencies.